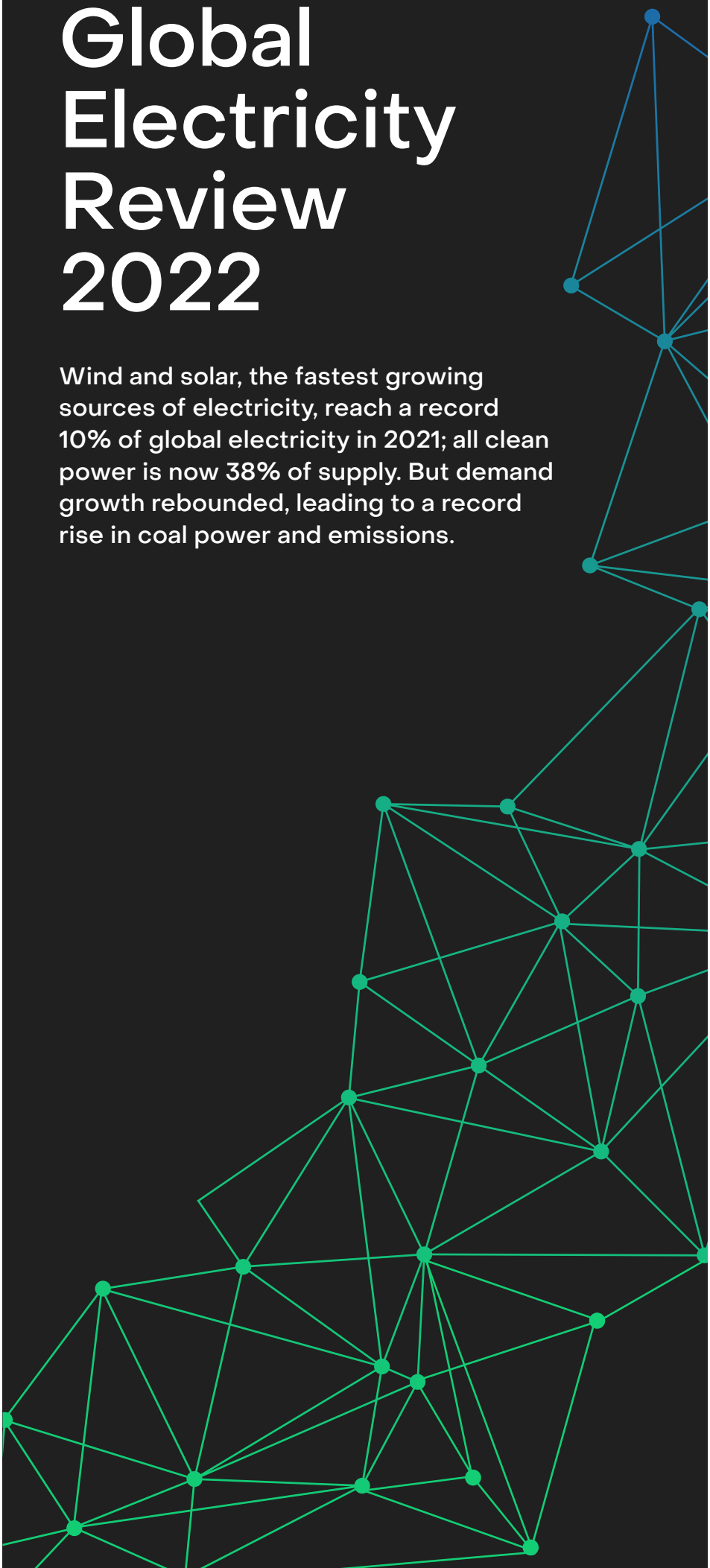
Global Electricity Review 2022

Wind and solar, the fastest growing sources of electricity, reach a record 10% of global electricity in 2021; all clean power is now 38% of supply. But demand growth rebounded, leading to a record rise in coal power and emissions.



EMBER

Publication date
March 2022

EMBER

COAL TO CLEAN ENERGY POLICY

About

Ember's third annual Global Electricity Review aims to provide the most transparent and up-to-date overview of changes in the global electricity transition in 2021. We make all of the data freely accessible to allow others to do their own analysis and help speed the switch to clean electricity.

We are witnessing extraordinary events in relation to our global security and global energy systems. We expect a turbulent year ahead. Even as these immediate issues must draw our attention, we know that the longer term, severe threat of climate change is only growing. We will therefore continue to monitor and report on the global impact of the electricity sector and to advocate for an effective and urgent transition to a zero emissions system, which will ultimately also help reduce our energy insecurity and exposure to geopolitical risks.

Our dataset comprises annual power generation and import data for 209 countries covering the period 2000 to 2020. For 2021, we have added data for 75 countries which together represent 93% of global power demand.

This summary report — and the data behind it — is an open resource. Reliable and transparent tracking of the global electricity sector is critical to ensure effective action at the time and scale needed to keep global heating to 1.5 degrees. Alongside this analysis, we offer the comprehensive data set freely available to download or explore via our data explorer.

Ember is an independent, not-for-profit think tank. We gratefully acknowledge the philanthropic organisations that have funded us, including the European Climate Foundation, Quadrature Climate Foundation, Bloomberg Philanthropies and ClimateWorks — and thanks to everyone who has donated at the Crowd.

Data contributors

Maciej Zieliński; Jeremy Fletcher; Matt Ewen; Nicolas Fulghum; Pete Tunbridge

Analysis contributors

Dave Jones; Aditya Lolla; Alison Candlin; Bryony Worthington; Charles Moore; Hannah Broadbent; Harry Benham; Muyi Yang; Phil MacDonald

Document design & layout by Diva Creative

Contents

Executive summary

Record wind and solar – but also record coal and emissions

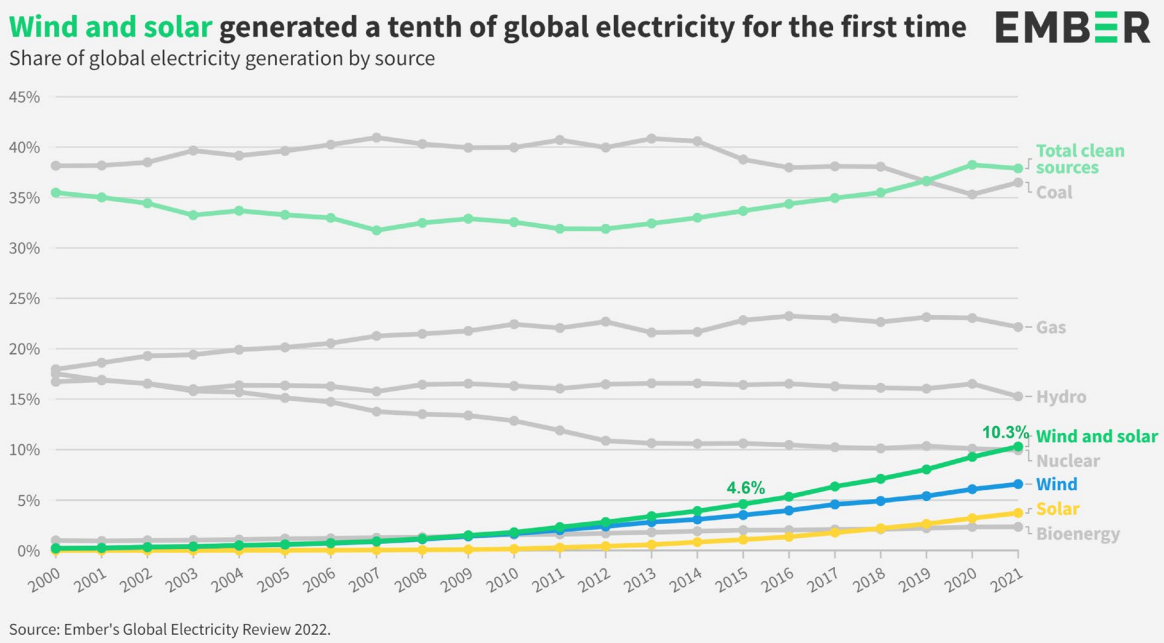
Wind and solar hit a tenth of global electricity, but the global electricity transition needs to sustain very high growth rates to replace coal and reduce emissions.

Solar generation rose 23% last year, and wind by 14%. Combined, this takes them to more than 10% of global electricity generation. All clean electricity sources generated 38% of the world's electricity in 2021, more than coal (36%).

To be on a pathway that keeps global heating to 1.5 degrees, wind and solar need to sustain high compound growth rates of 20% every year to 2030. That's the same rate of growth as their average over the last decade.

This is now eminently possible: wind and solar are the lowest cost source of electricity on a levelised basis, with ever-increasing global experience of integrating them into grids at high levels. With 50 individual countries now generating more than 10% of their electricity from these quick-to-deploy resources, and three countries already generating over 40%, it is already clear that these technologies are delivering.

Governments like the US, Germany, UK and Canada are so confident in clean electricity that they are planning to shift their grid to 100% clean electricity within the next decade and a half. But with coal still rising and electricity demand continuing to increase, all governments with carbon intensive grids now need to act with that same boldness and ambition.



01

Wind and solar - the fastest growing sources of clean electricity - hit a tenth of global electricity

Wind and solar generated over a tenth (10.3%) of global electricity for the first time in 2021, rising from 9.3% in 2020, and twice the share compared to 2015 when the Paris Climate Agreement was signed (4.6%). Combined, clean electricity sources generated 38% of the world's electricity in 2021, more than coal (36%).

50 countries have now crossed the 10% wind and solar landmark, with seven new countries in 2021 alone: China, Japan, Mongolia, Viet Nam, Argentina, Hungary and El Salvador. Three countries — the Netherlands, Australia and Viet Nam — shifted over 8% of their total electricity demand from fossil fuels to wind and solar in just the last two years.

02

High demand growth outstripped clean power

Electricity demand rebounded, rising by the most ever in absolute terms: 1,414 TWh from 2020 to 2021, approximately the equivalent of adding a new India to the world's electricity demand. At +5.4%, 2021 saw the fastest demand growth since 2010. Many advanced economies rebounded back to pre-pandemic levels after falls in 2020.

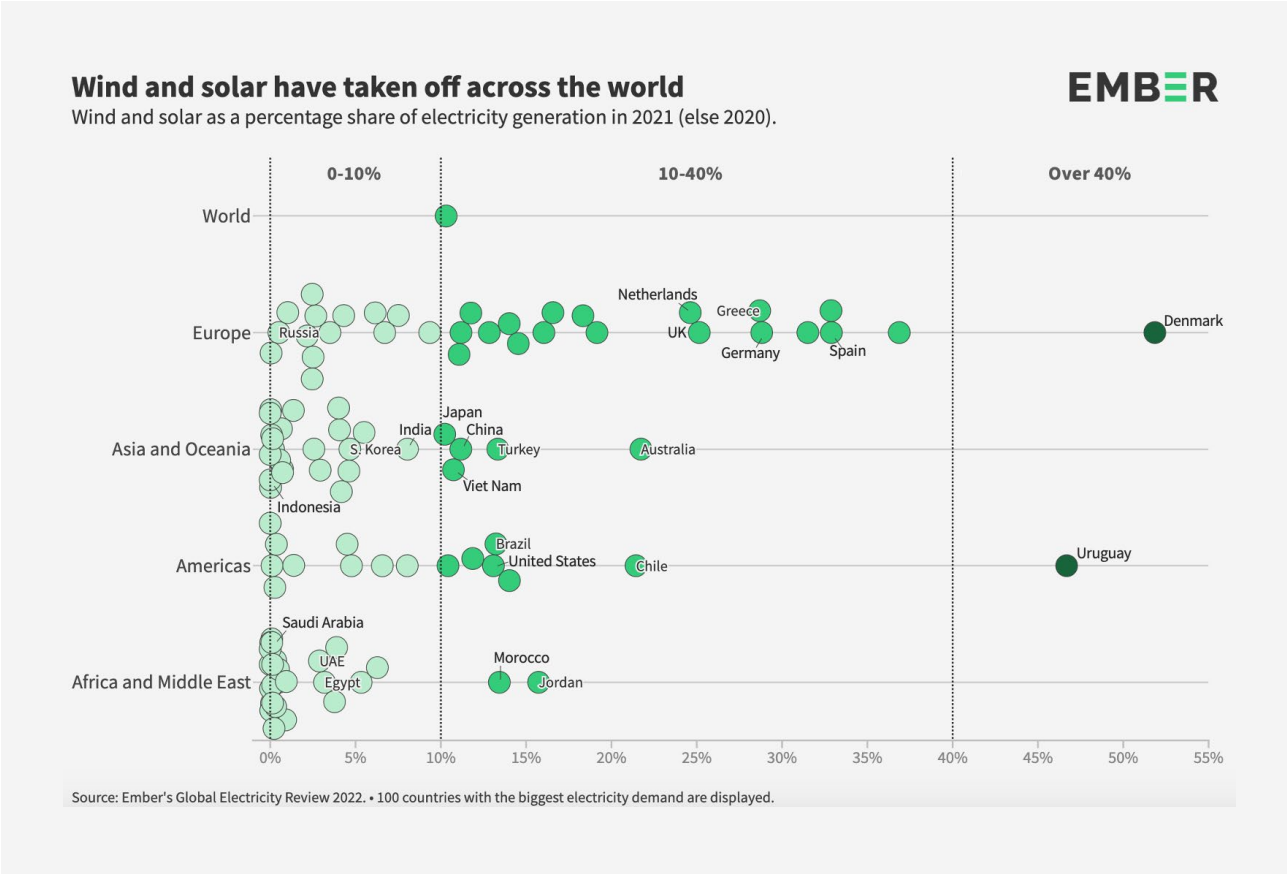
But the real growth was in Asia, in large part as economic growth boomed; China saw the biggest rise, with 13% higher demand in 2021 than in 2019.

Despite a record rise in wind and solar generation, only 29% of the global rise in electricity demand in 2021 was met with wind and solar. Other clean electricity provided no growth, with nuclear and hydro levels unchanged for two years. Remaining demand increase was therefore met by fossil fuels. 59% of the electricity demand rise in 2021 was met by coal generation alone.

03 Coal power rose to a new record

Coal power rose by 9.0% in 2021 to 10,042 TWh, a new all-time high and 2% above the previous record set in 2018. It was the biggest percentage rise on record since at least 1985, taking coal generation to 36% of global electricity.

New coal records were set throughout Asia in 2021, where electricity demand boomed, including in China (+9%), India (+11%), Kazakhstan (+6%), Mongolia (+13%), Pakistan (+8%), the Philippines (+8%) and most likely Indonesia (data not yet available).



In 2021, coal power in the US, EU and Japan strongly rebounded compared to 2020, but remained below 2019 levels. China's share of global coal power rose from 50% in 2019 to 54% in 2021.

The record rise in coal was not matched by global gas generation, which increased by only 1% in 2021. 62% of the world's electricity came from fossil fuels in 2021, up from 61% in 2020 — the first year since 2012 that fossil fuel's share has risen.

04

Power sector emissions at an all-time high

Power sector CO2 emissions rose to an all-time record, beating the previous record in 2018 by 3%. They rose by 7% in 2021 (778 million tonnes) — the biggest percentage rise since 2010, and the biggest absolute rise ever. The 7% rise follows a fall of just 3% in 2020, putting emissions higher than before the pandemic struck.

"Wind and solar have arrived. The process that will reshape the existing energy system has begun. This decade they need to be deployed at lightning speed to reverse global emissions increases and tackle climate change.

Even as coal and power emissions hit another all-time high, there are clear signs that the global electricity transition is well underway. More wind and solar is being added to grids than ever. And not just in a few countries, but across the world. They are able — and expected — to provide the majority of clean electricity needed to phase out all fossil fuels, at the same time helping to increase energy security.

But with sustained high gas prices amid Russia's war with Ukraine, there is a real risk of relapse into coal, threatening the global 1.5 degrees climate goal.

Clean electricity now needs to be built on a heroic scale. Leaders are only just waking up to the challenge of how quickly they need to move to 100% clean electricity."

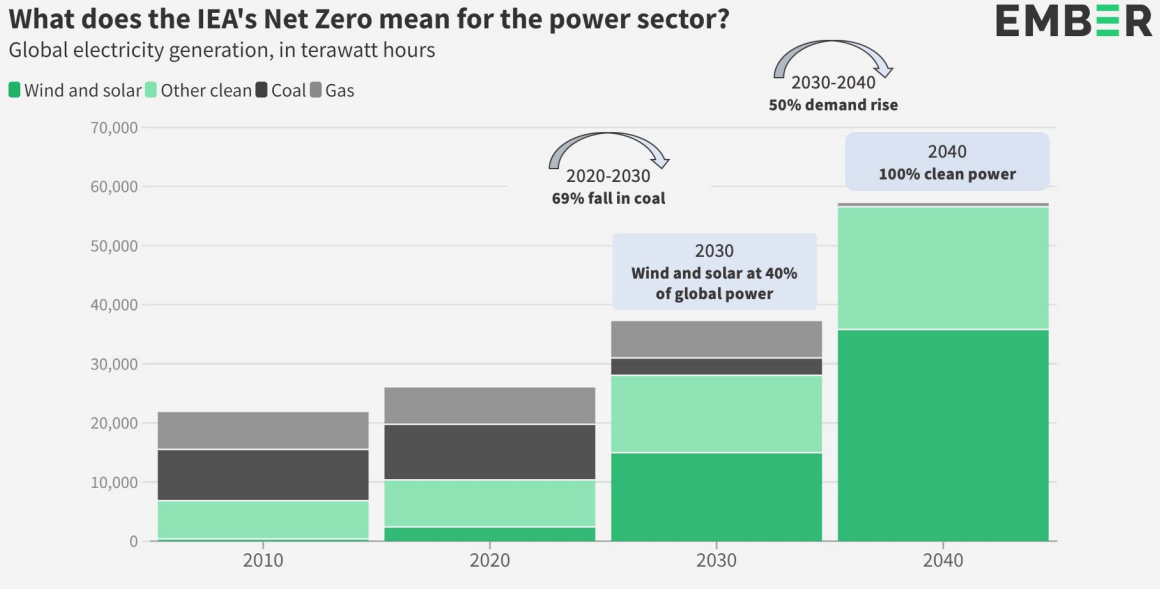
Dave Jones
Global lead, Ember

Global trends

Trends in global electricity

Introduction: The challenge ahead

The electricity sector shoulders the biggest burden on the pathway to keeping global heating to no more than 1.5 degrees. In May 2021, the International Energy Agency (IEA) published its monumental Net Zero by 2050 report, which shows the electricity sector needs to move from being the highest emitting sector in 2020, to being the first sector to hit net zero globally by 2040. At the same time, widespread electrification means the electricity sector will massively expand, helping to decarbonise other sectors.



Source: IEA Net Zero by 2050 Report.
Other clean includes: Hydro, nuclear, bioenergy, BECCS, fossil fuels with CCS, hydrogen-based, geothermal, marine

The previous graphic, using IEA data and milestones, highlights the scale of the electricity transition.

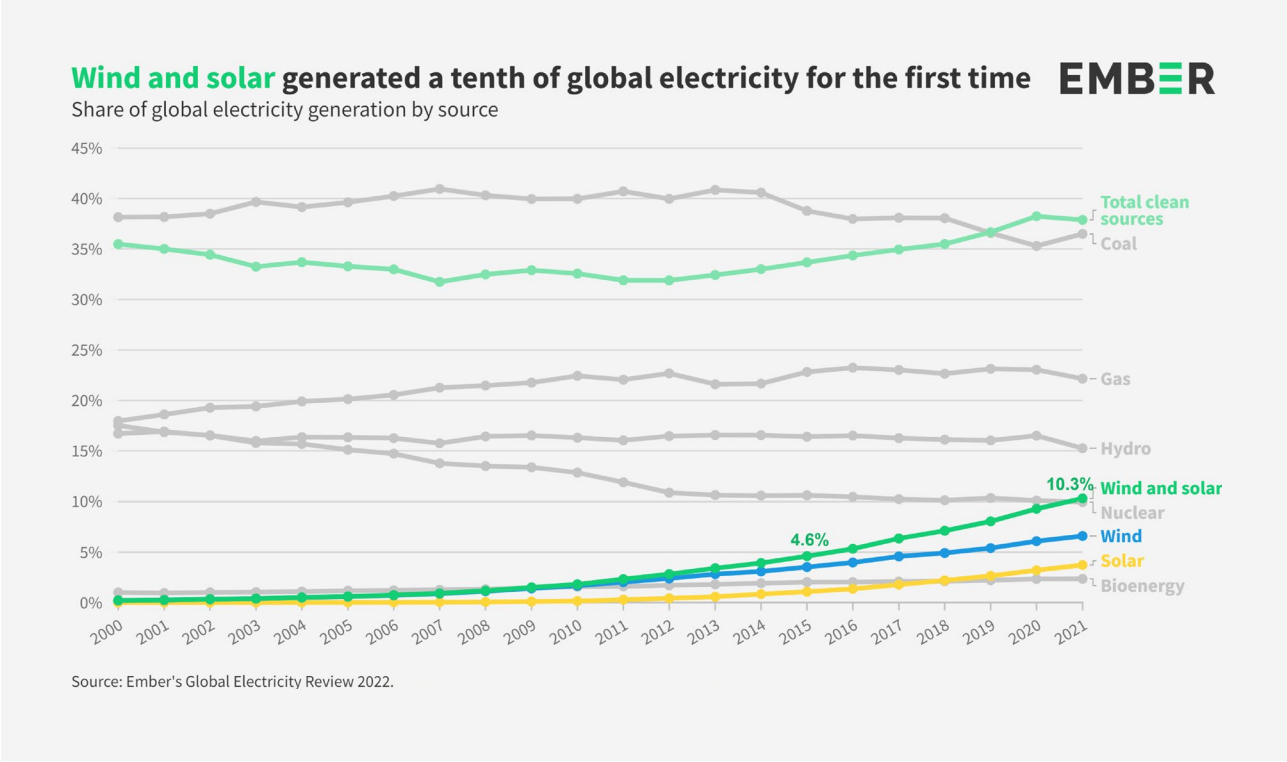
In this report, we track progress against the IEA's Net Zero by 2050 pathway to ask the critical question: Is the electricity transition happening fast enough to keep global heating to 1.5 degrees?

1. Wind and solar surpass 10%

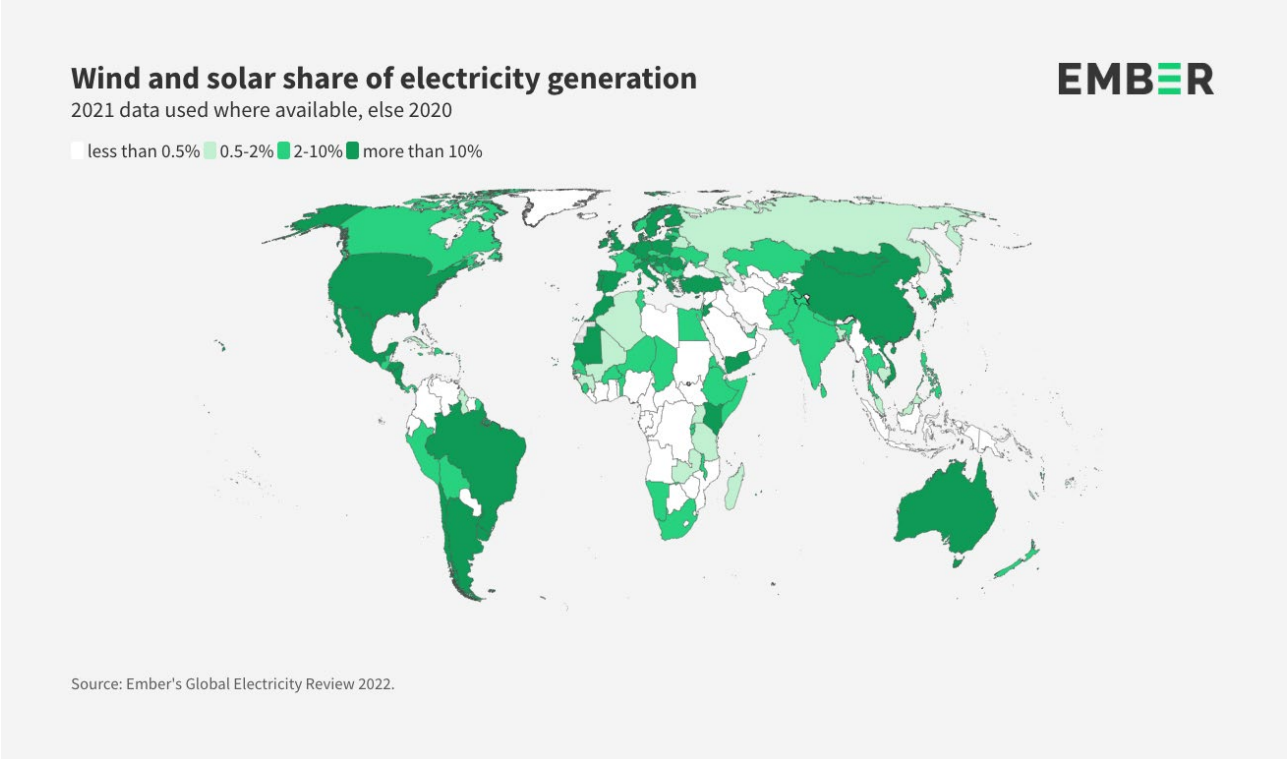
Wind and solar now a tenth of global electricity

Wind and solar generated over a tenth (10.3%) of global electricity for the first time in 2021, up from 9.3% in 2020. This is more than double the market share (4.6%) from when the Paris agreement was signed in 2015. Their growth rate has also increased: wind generation rose by +14% in 2021 (the highest since 2017), and solar by +23% (the highest since 2018); combined, they rose by 17%. This wind and solar growth was slower in 2021 than last decade, when they had an average of 20% year-on-year growth.

Clean electricity sources generated 38% of the world's electricity in 2021. Taken together, wind and solar are now the fourth largest source of electricity in the world. They were also the fastest-growing clean sources in 2021;



other zero emissions sources of electricity either fell (hydro) or were roughly static (bioenergy and nuclear). Fossil fuels still generated 62% of global electricity; mainly coal (36%) and gas (22%).



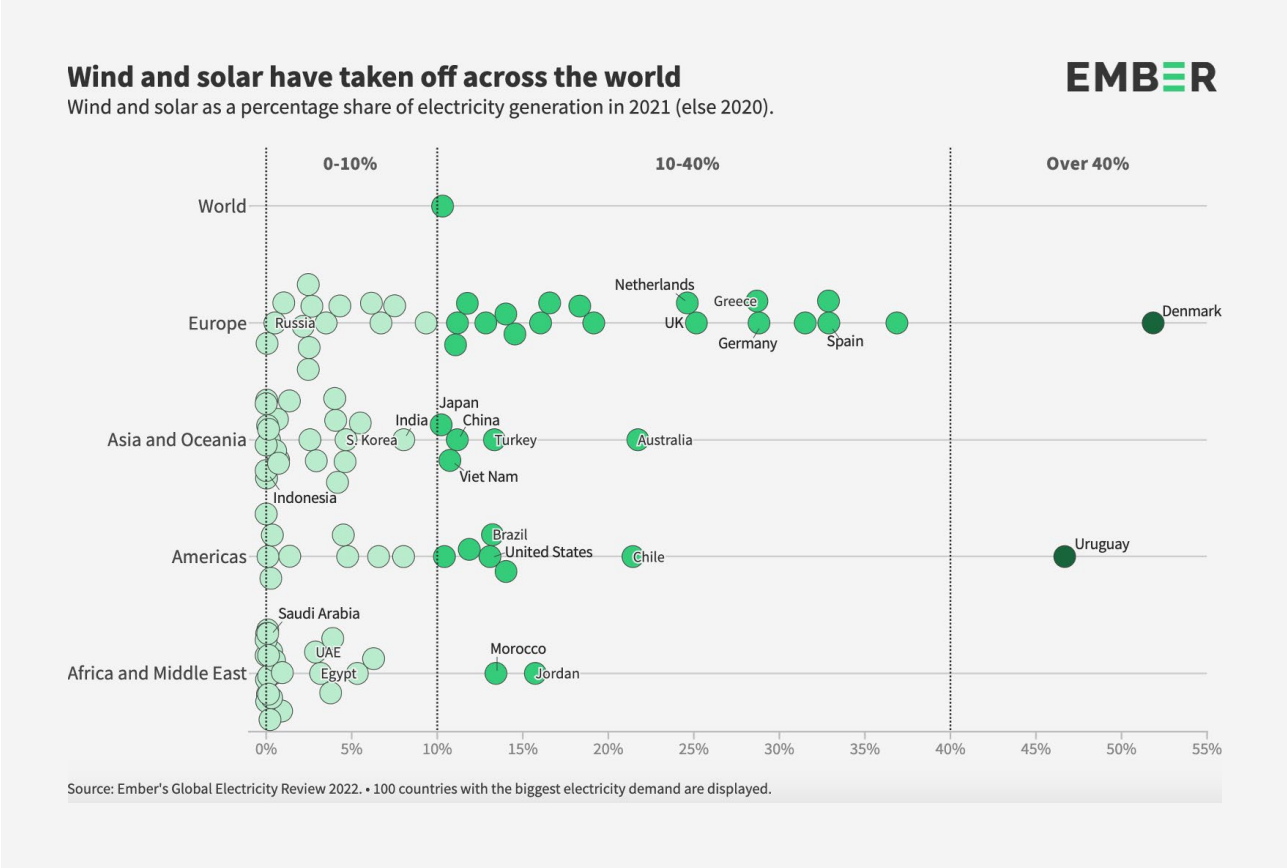
50 countries now above 10% wind and solar

50 countries had over a tenth of their electricity from wind and solar in 2021, up from 43 in 2020 and 36 in 2019. Seven countries hit this landmark in 2021 for the first time: China (11.2% in 2021), Japan (10.2%), Mongolia (10.6%), Viet Nam (10.7%), Argentina (10.4%), Hungary (11.1%) and El Salvador (12.0%).

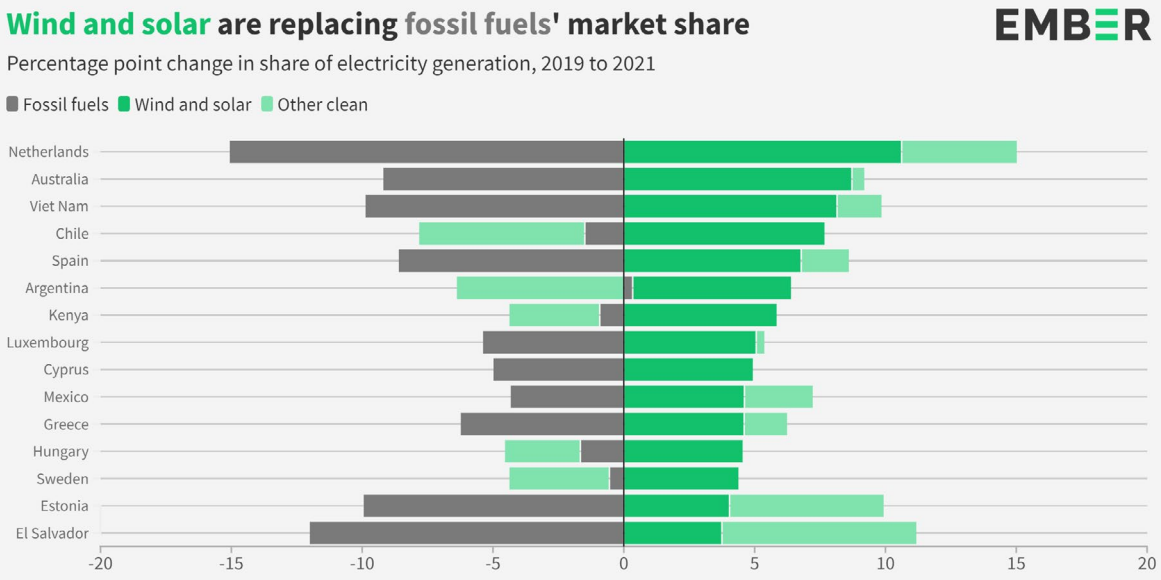
All five of the world's largest economies have reached this landmark: the US, China, Japan, Germany and the UK. Europe leads the way with nine of the ten top countries. Three countries have even exceeded 40% of their electricity from wind and solar. In 2021, Denmark, Luxembourg and Uruguay achieved 52%, 43% and 47% respectively, leading the way on technology for high renewable grid integration.

The Middle East and Africa had the fewest countries reach a landmark tenth of wind and solar. Saudi Arabia's electricity is still less than 1% wind and solar, and the next two hosts of UN climate summits — Egypt and the UAE — have only 3%.

The countries which have transformed their electricity system the fastest since the pandemic were the Netherlands, Australia and Viet Nam. From 2019 to 2021, they switched over 8% of their total electricity demand to wind and solar.



What's more, that new wind and solar directly replaced fossil fuels. In the Netherlands, the share of wind and solar rose from 14% to 25% in just two years, whilst the share of fossil fuels fell from 78% to 63%. In Australia, wind and solar rose from 13% to 22%, whilst the share of fossil fuels fell from 79% to 70%. In Viet Nam, the share of wind and solar rose from 3% to 11%, whilst the share of fossil fuels fell from 73% to 63%. If these trends can be replicated globally, and sustained, the power sector would be on track for 1.5 degree goal.



Viet Nam's solar boom

Viet Nam has seen unparalleled growth in solar power. This has not only reduced power sector emissions, but also reduced its costly gas import bill. In 2021, Viet Nam saw astonishing growth in solar as it increased its generation by 337% (+17 TWh) in a single year, to become the world's 10th largest solar generator. This solar growth meant that Viet Nam was the only country in Asia to meet and exceed its entire demand rise with new wind and solar.

The solar increase, even as demand grew, reduced fossil fuel share, with coal down from 55% to 52%, and gas from 17% to 12% — driving emissions down by a significant 6%. Viet Nam's combined wind and solar capacity has increased by four times since 2019. Another four-fold increase to 89 gigawatts by 2030 would be enough to match all their increase in demand even in a high electricity growth scenario.

When rapid renewables growth happens, the rest of the electricity system needs to adapt quickly, and in Viet Nam's case, there are some key lessons.

The feed-in-tariffs were so popular they were put on hold. But to get the cheapest prices, countries need a long-term renewables policy to create a stable investment environment; stop-start policy needs to be avoided.

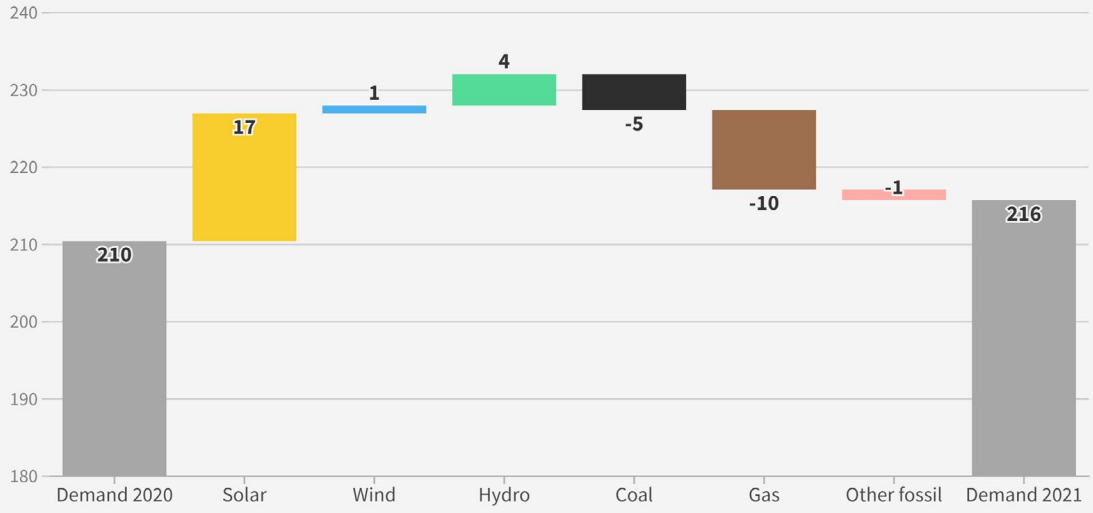
The grid also had problems integrating such large amounts. More upfront planning would have helped, to strengthen the grid and add sufficient interconnection, alongside flexible demand and storage capacity.

This rapid growth poses some very interesting questions in relation to plans for a new thermal plant. Viet Nam has made a high level commitment to stop building new coal plants, and yet there are still new coal plants in planning, and an incredible 56 gigawatts of planned gas power plants. The speed and cost of the solar boom, if well managed, could undermine the investment case significantly.

Viet Nam's solar boom reduced coal and gas generation in 2021

EMBER

Electricity generation, in terawatt hours

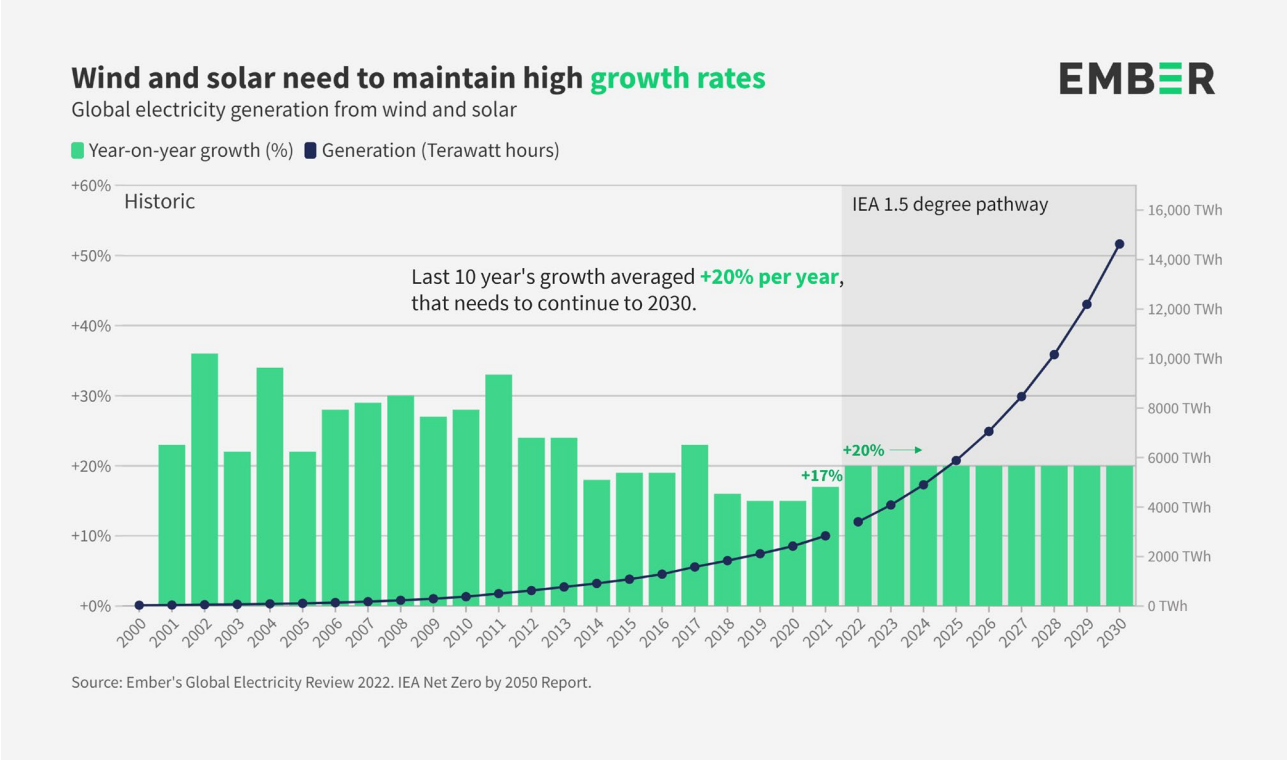


Source: Ember's Global Electricity Review 2022. 2021 net imports data was not available.

Wind and solar need to sustain high growth rates for 1.5 degrees

The IEA's 1.5 degree pathway shows wind and solar as the powerhouse of clean electricity, providing three-quarters of all new clean electricity to become 40% of the world's electricity by 2030, up from 10% now.

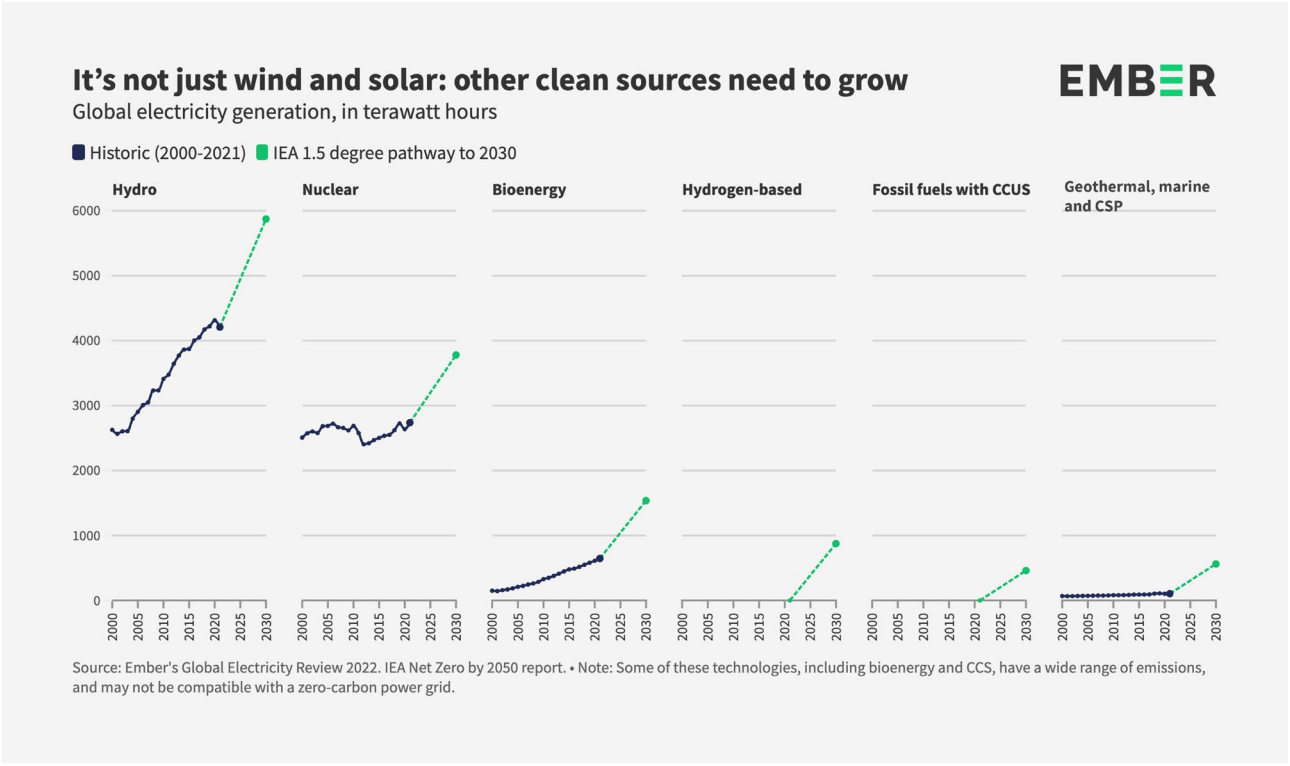
To increase generation from 2,837 TWh in 2021 to the 14,978 TWh needed by 2030 means 20% compound growth every year. In the last decade, wind and solar achieved an average 20% per year, and although the growth rate had been falling, it picked back up to 17% in 2021. Compound growth of 20% has been done before, and it needs to be done again.



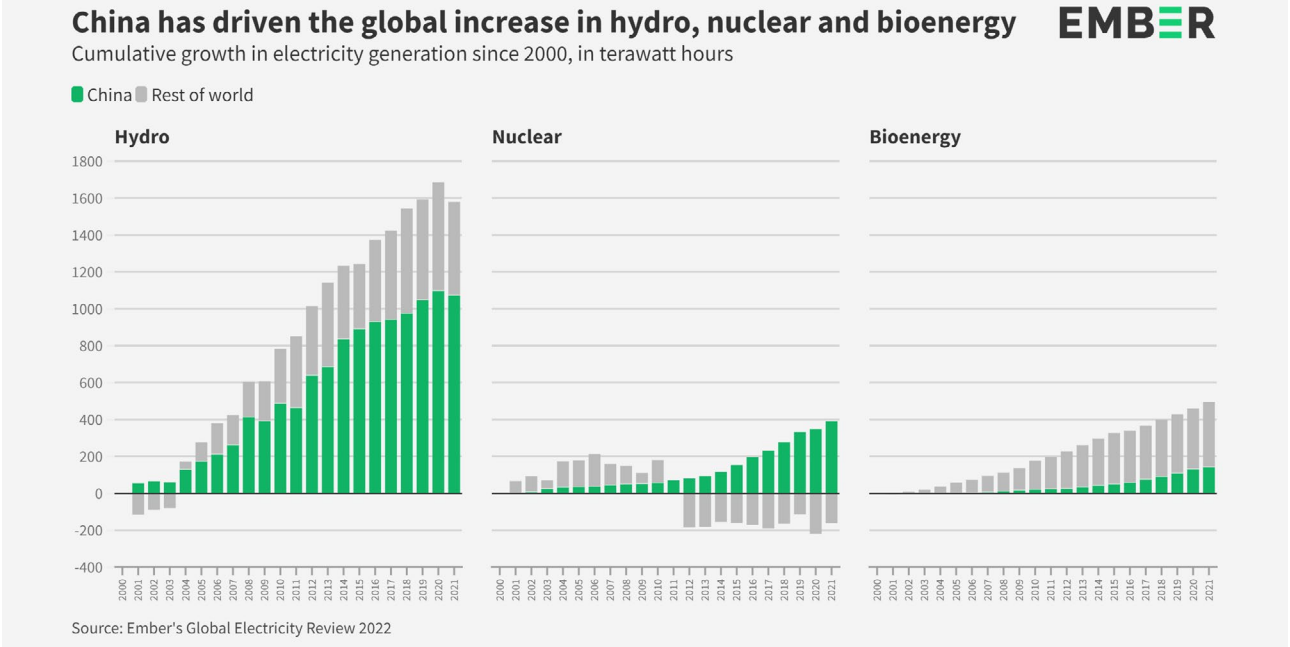
2. Growth of other clean electricity sources stalled

Growth in clean generation, other than wind and solar, stalled in 2021. Hydro fell 2% on drier conditions, especially in China. Nuclear increased 4% as existing reactors in France and Japan came back online and new reactors switched on in China and Russia. Bioenergy grew 6%, although concerns continue to be raised about its true emissions impact. Emerging technologies commonly included in Net Zero pathways still provide no meaningful electricity generation: including fossil fuels with carbon capture, hydrogen-based fuels, CSP (concentrated solar power), geothermal and marine.

Although wind and solar are the fastest growing sources of clean electricity, the IEA Net Zero by 2050 report anticipates that a quarter of the growth in clean electricity will still come from other technologies. These other technologies generally complement, rather than compete with, wind and solar. In particular, they provide benefits to the grid to support the variability of wind and solar. Stalling on these complementary technologies will make it even more difficult to achieve the emissions cuts needed by 2030. An alternative IEA scenario suggests that it's possible to decarbonise without bioenergy and CCS, but the IEA forecast it would likely increase the cost of reaching zero carbon power.



Life-cycle assessments reported by the IPCC find hydro and nuclear are extremely low-carbon sources of power generation. However, dependent on the capture-rate of CCUS, the technology can still produce significant emissions. Bioenergy has the highest emissions risk, with a wide range dependent on sourcing. More information is available in our methodology.



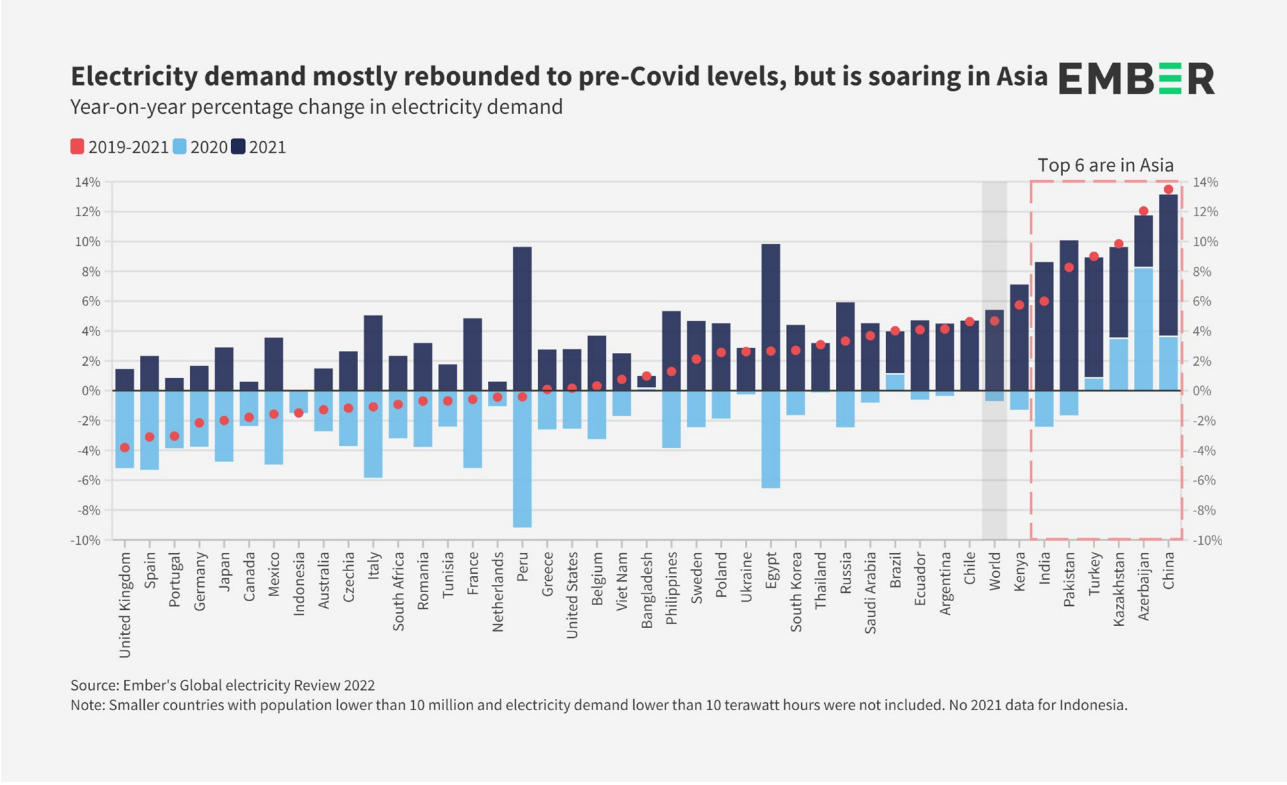
China driving growth of hydro, nuclear and bioenergy

Growth in bioenergy, hydro and nuclear in the last 20 years was led by China. Since 2000, China has provided two-thirds of the global growth in hydro generation, all the net growth of nuclear, and a third of the growth in bioenergy. The majority of the growth in hydro outside China was in India, Brazil and Russia. The majority of the growth in bioenergy outside China was in the UK, Japan, India and Brazil.

3. High demand growth

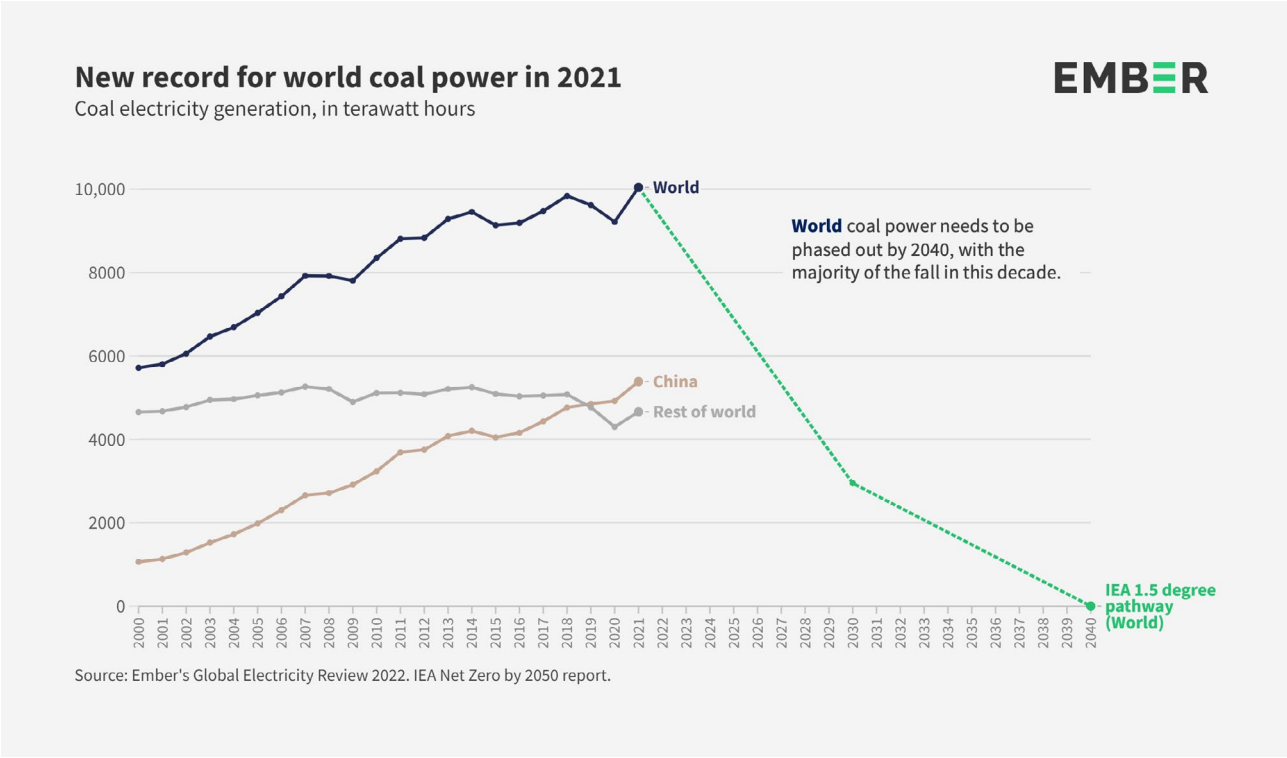
Electricity demand rose by the most ever in absolute terms: 1,414 TWh from 2020 to 2021 — approximately the equivalent of adding a new India to the world's electricity demand. At 5.4%, 2021 saw the fastest demand growth since 2010. The rise followed from a small 1% fall in 2020.

Many advanced countries rebounded after the fall in 2020, back to pre-pandemic levels. Some countries had levels slightly lower than pre-Covid, such as the UK (4% lower in 2021 than in 2019), Germany (-2%) and Japan (-2%). But most developed countries, including the US, rebounded back to 2019 demand levels. Poland (+3%), Korea (+3%) and Russia (+3%) were all slightly higher.



Source: Ember's Global electricity Review 2022
Note: Smaller countries with population lower than 10 million and electricity demand lower than 10 terawatt hours were not included. No 2021 data for Indonesia.

The real growth continues to be in Asia, in large part as economic growth boomed. In many countries, it followed on from a growth year even in 2020 when the pandemic struck. China saw the biggest rise, with 14% higher electricity demand in 2021 compared to 2019.

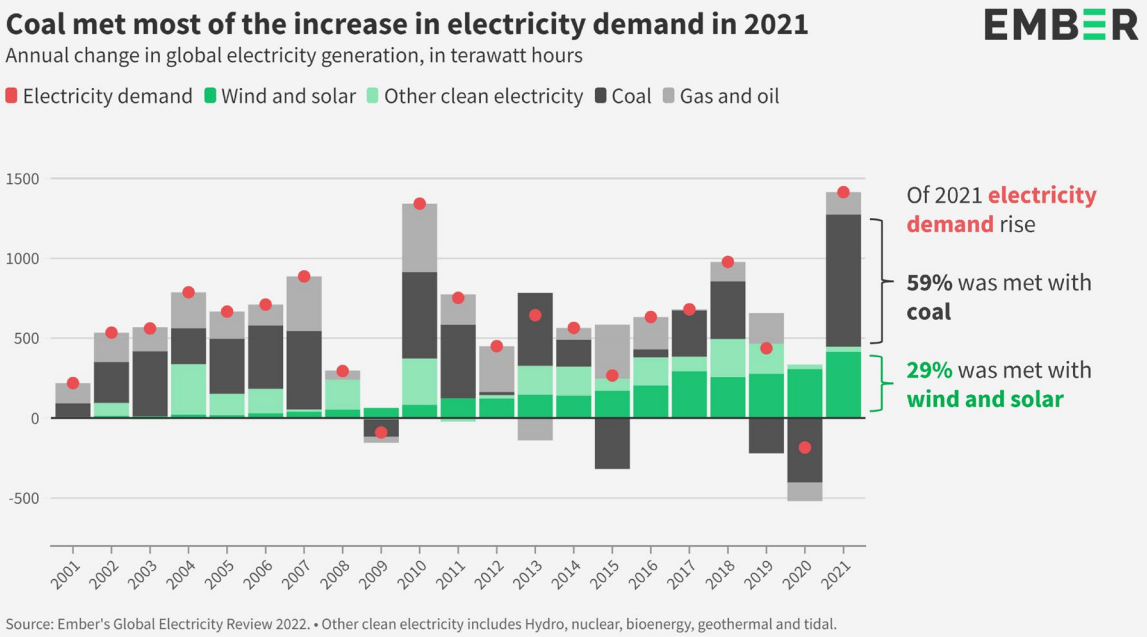


4. Record coal power

Coal power rose by 9.0% in 2021 to 10,042 TWh, more-than rebounding from a 4.2% fall in 2020. It was the biggest percentage rise on record since at least 1985. This pushed coal to set a new record for global power generation, beating the previous record of 9,838 TWh in 2018 by 2%. It reached 36.5% of global electricity, up from 35.3% in 2020. China's share of global coal power was unchanged at 54% in 2021, having risen from 50% in 2019 to 54% in 2020. For the IEA's 1.5 degree pathway, unabated coal power generation must fall by 73% globally from 2021 to 2030. Coal's new 2021 record shows just how far off-track the electricity transition is.

Why did coal increase?

Coal power rose in 2021 because clean electricity simply was not deployed quickly enough to keep up with unprecedented demand growth.



Despite a record rise in wind and solar generation, only 29% of the global rise in electricity demand in 2021 was met with wind and solar. Other clean electricity provided no net growth, with nuclear increasing but hydro falling. Remaining demand increase was therefore met by fossil fuels. 59% of the electricity demand rise in 2021 was met by coal generation alone. Gas and oil made up the final 10%.

China and India

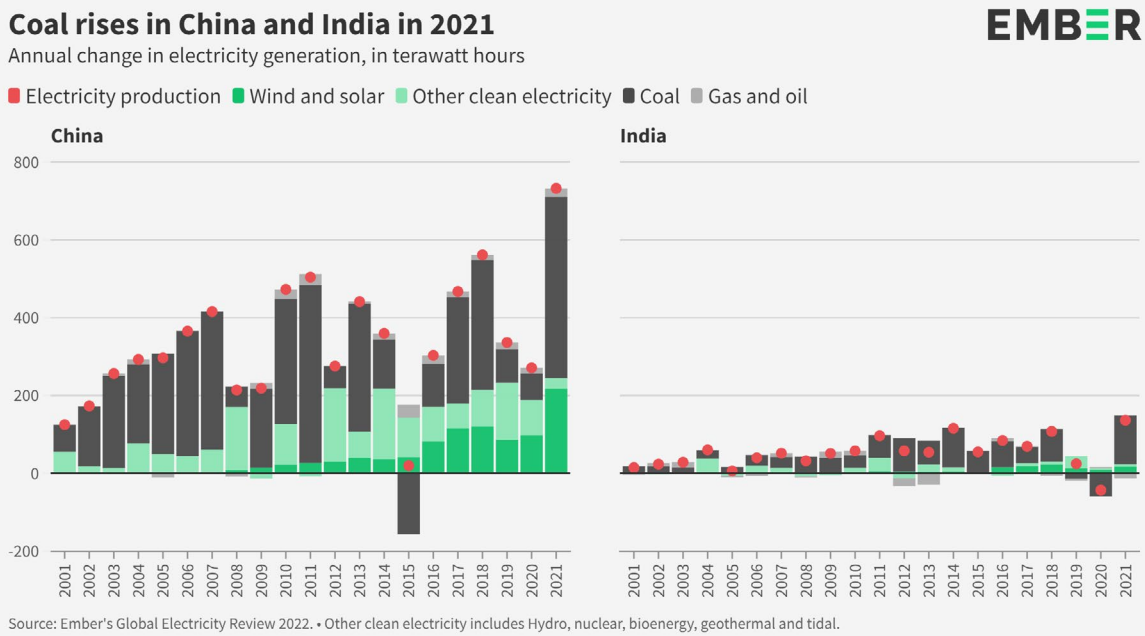
China and India are the world's #1 and #2 biggest coal power countries. They both set new coal power records in 2021.

China's coal generation rose by 466 TWh (9.5%) in 2021, an increase equal to the combined coal generation of Japan and Germany in 2021. It is now twice the level it was in 2008, and setting a new coal record for the fifth year in a row. It was the first time since 2011 that China's coal market share didn't fall, staying constant at 63.6%.

China's clean electricity rose fast in 2021: wind generation grew 32%, solar 27%, bioenergy 8% and nuclear 11%. Hydro fell slightly, due to adverse weather, but is structurally growing. Gas generation rose by 8%. However, clean electricity was only enough to meet 33% of China's rise in electricity demand, which increased by +9.5% in 2021. Coal filled the gap, meeting 64% of the electricity demand rise.

India's coal generation rose by 125 TWh (11%) in 2021, setting a new record, beating the previous high in 2018 by 4%. Coal market share rose from 72% to 74% of India's electricity. The increase in wind and solar generation was only the third highest on record, and met only 12% of the increase in electricity demand — coal filled the gap.

There were also all-time coal power records set in other Asian countries in 2021: Kazakhstan (+6%), Mongolia (+13%), Pakistan (+8%), and the Philippines (+8%).

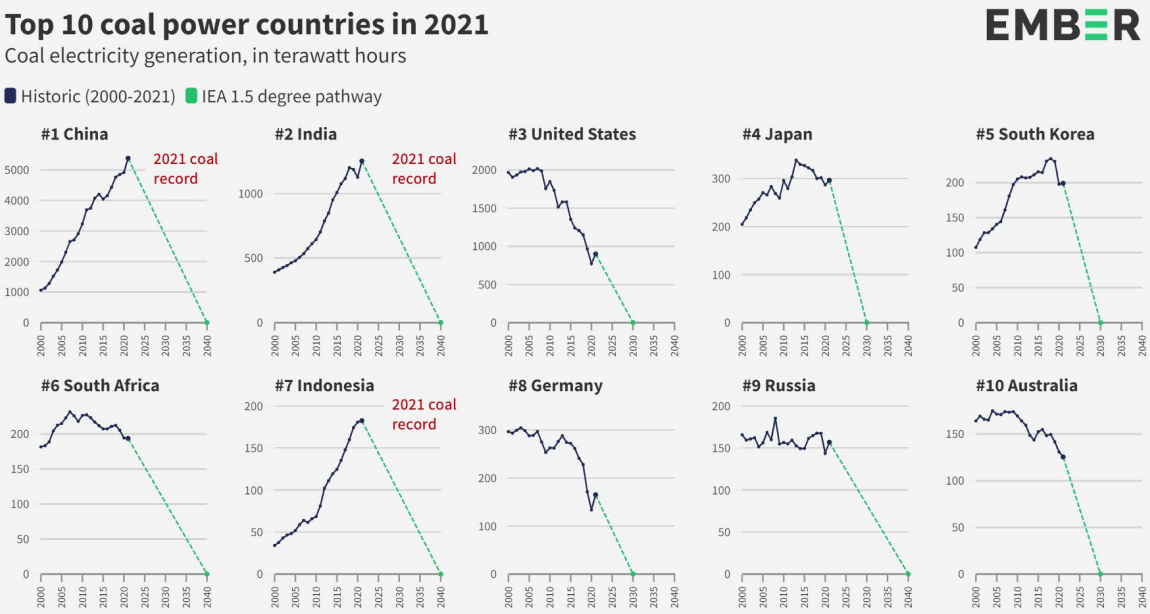


Top ten coal countries

The top ten coal power countries accounted for 90% of the world's coal power generation in 2021.

Coal power in the US, EU and Japan strongly rebounded compared to 2020, but remained below 2019 levels. The US rebounded 16% in 2021, but was 7% below 2019 levels, Germany rebounded 24% in 2021, but was 4% below 2019 levels, Japan rebounded 3% in 2021, but was 2% below 2019 levels.

The rebound in coal was mostly caused by the rebound in electricity, but it was also partly exacerbated by a rise in gas prices. A switch from gas generation to coal generation happened at three points in 2021: in Europe at the end of the year as gas prices spiked, in the US during the Texan crisis in February 2021, and in Japan.



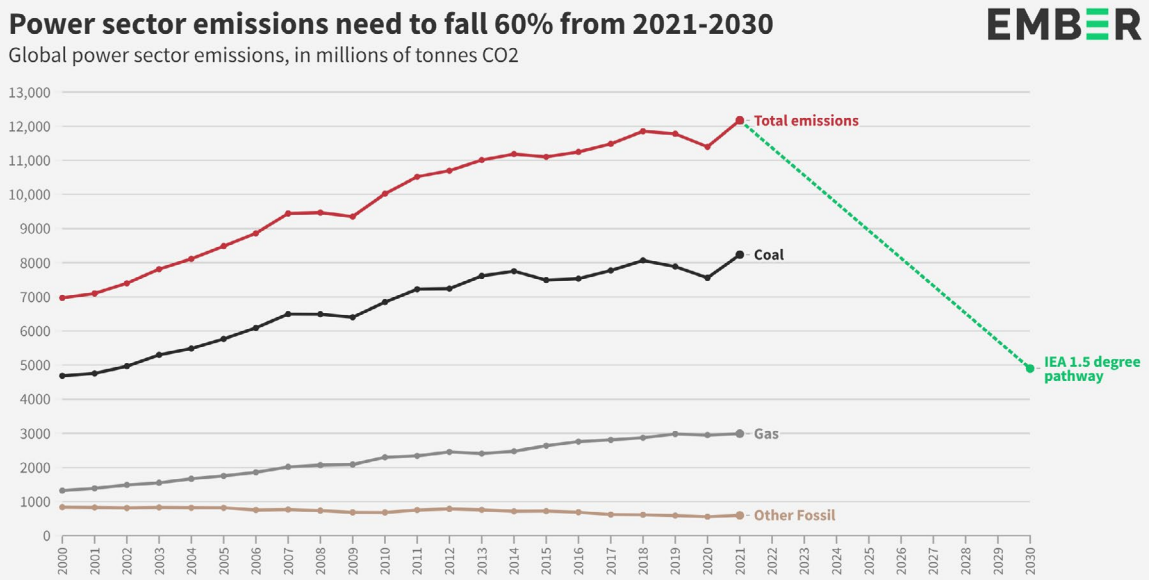
As the high gas prices continue into 2022, our analysis for Europe finds that the gas crisis is interrupting the EU's coal exit, and identifies a 'paradigm shift' as new renewables replace gas instead of coal. This new feature of the market only partly impacted full-year 2021 data, but will undoubtedly impact 2022 and beyond.

For the IEA 1.5 degree pathway, OECD countries will have to phase out coal by 2030, and the rest of the world by 2040. So far, of the remaining top 10 coal countries, only Germany has a commitment to phase out by 2030.

5. Record emissions rise

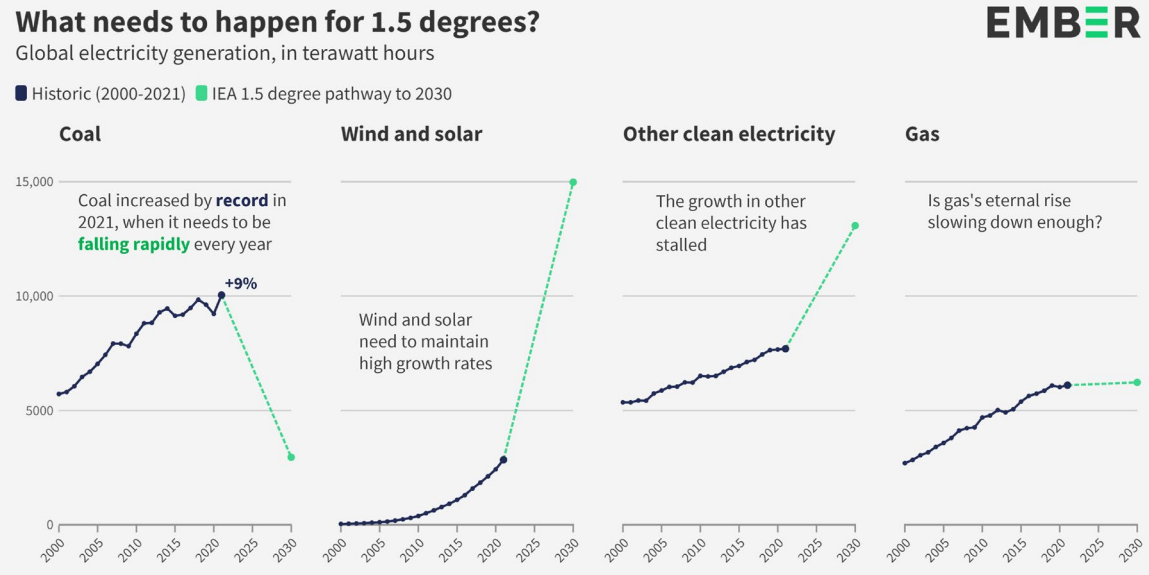
The record rise in coal, coupled with a modest rise in gas generation, means power sector CO2 emissions rose by 7% (778 million tonnes) in 2021. That's the largest absolute rise ever, and the largest percentage rise since 2010. This rise follows from a fall in 2020, but that fall was only 3%. This takes power sector emissions to a new record of over 12 billion tonnes of CO2, beating the previous record in 2018 by 3%. Emissions growth is in sharp contrast to what is needed for the IEA's 1.5 degrees pathway: a 60% fall in power sector emissions from 2021 to 2030.

The future electricity system is expected to more than triple in size under a net zero global energy scenario, displacing fossil fuel use in other sectors and bringing



Source: Ember's Global Electricity Review 2022. IEA Net Zero by 2050 report. CO2 emissions calculated from standard IPCC fuel emissions factors; details in report methodology.

down emissions overall. However, in the interim, [though demand for oil in 2021 remained suppressed](), an increase in electricity demand was met predominantly through fossil fuels and this pushed up both electricity emissions and total global emissions to record levels. Over time, continued electrification, coupled with clean electricity deployment increases, will turn global emissions around.



Source: Ember's Global Electricity Review 2022. IEA Net Zero by 2050 report.
Other clean electricity includes: Nuclear, hydro, bioenergy, other renewables, hydrogen and fossil CCS

Moving to clean power

Ember estimates global carbon intensity was 442g CO_2 per kWh in 2021 (up from 437g in 2020). The IEA 1.5 degree pathway means it must rapidly fall to zero by 2035 in advanced economies and by 2040 worldwide.

We already know what needs to happen — above all, wind and solar generation need to continue on their growth curve to provide three-quarters of the growth in clean electricity through to 2030. Leaders in wind and solar show that this level of market share is realistic, and that huge growth can happen relatively quickly. But those shifts aren't happening fast enough across all countries, and we're far off-track in reducing power sector emissions. The result in 2021 was coal's rise, at a time when it needs to be falling rapidly.

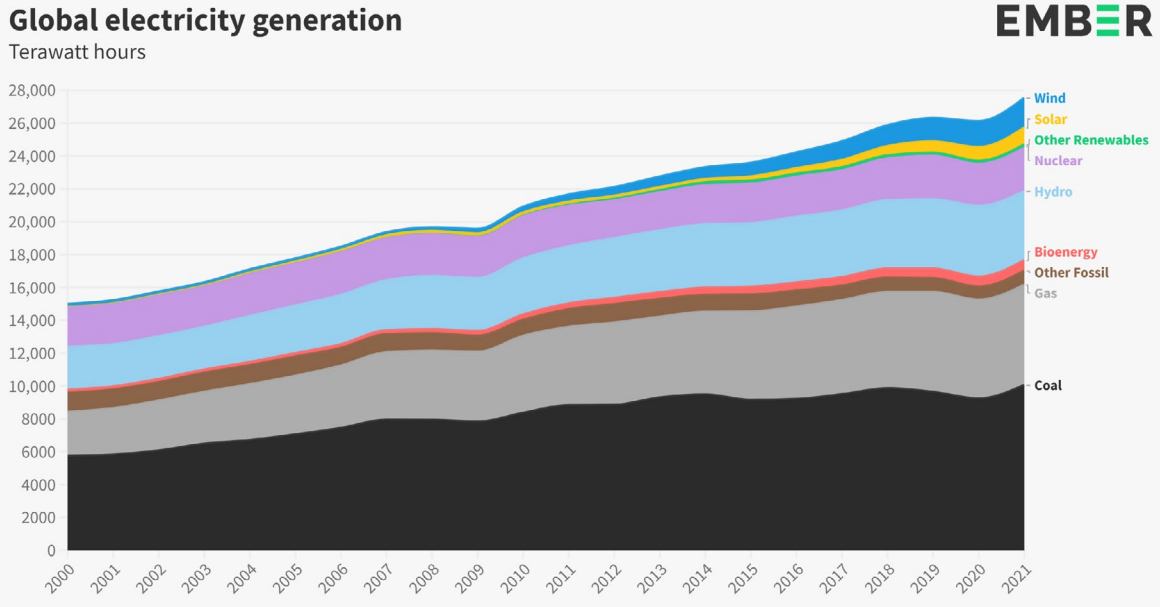
Data

Energy Sources

Analysis of the different global electricity sources in 2021

The following pages run through a more detailed analysis of the changes in supply of electricity over the last twelve months, and over a longer trend period. All of the graphics can be reproduced by accessing our data portal which now includes 2021 data.

We have ordered the sections according to the fastest growing sources of electricity.



Source: Ember's Global Electricity Review 2022

Solar

Change in 2021

Global solar generation rose 23% in 2021. It was the fastest rising source of electricity generation for the 17th year running. Generation rose year-on-year by 188 TWh to 1023 TWh.

Long term trend

Solar generated 3.7% of the world's electricity in 2021. This was up from just 1.1% in 2015, when the Paris Agreement was signed.

Leaders

Australia, with 12%, has the highest proportion of its electricity from solar of any major country in the world. Meanwhile, Viet Nam saw the biggest rise from 2% in 2020 to 10% in 2021. In Europe, Spain and the Netherlands saw the biggest growth, bringing their share to almost 10% of their total electricity.

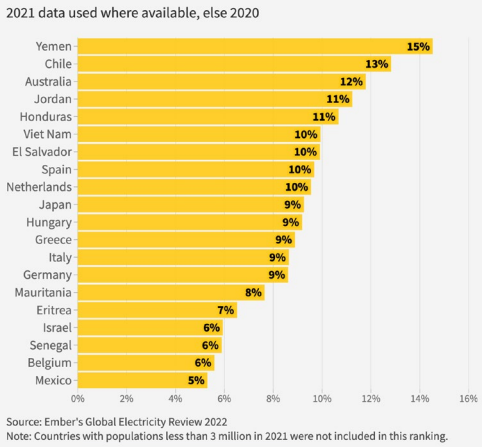
Laggards

Only 1% of global solar generation is in African countries and 2% in Middle Eastern countries (having 3% and 4% of global electricity demand respectively). India's solar generation saw its smallest year-on-year increase since 2016. Many eastern European countries have paused, with similar levels of solar generation in 2021 as to 2015 – notably, Bulgaria, Czechia, Romania, Slovakia and Slovenia.

On target for net zero?

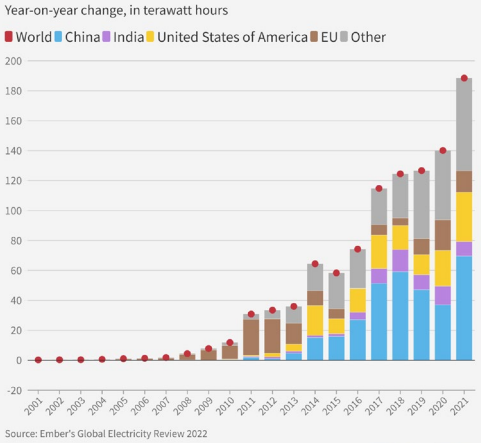
Solar generation needs to rise seven-fold by 2030, taking it from 4% of global electricity in 2021 to 19% by 2030. That means maintaining year-on-year growth of 24%; growth last year was 23%, and averaged 33% over the last ten years.

Which countries have the highest solar share of electricity generation?



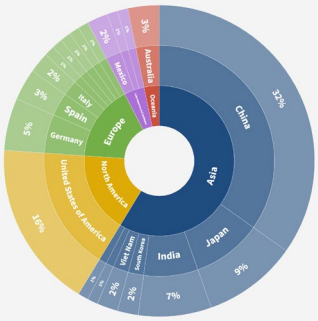
Source: Ember's Global Electricity Review 2022
Note: Countries with populations less than 3 million in 2021 were not included in this ranking.

Annual change in solar generation

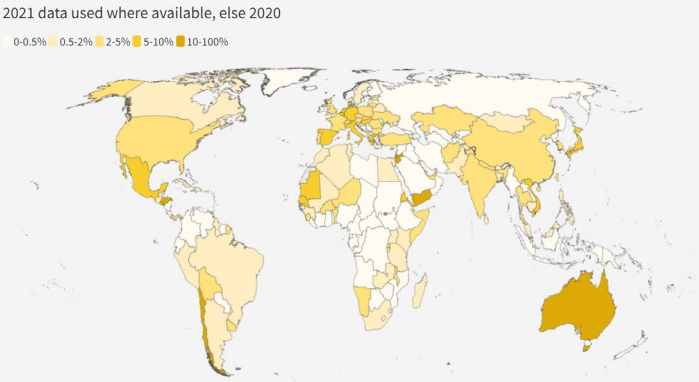


Source: Ember's Global Electricity Review 2022

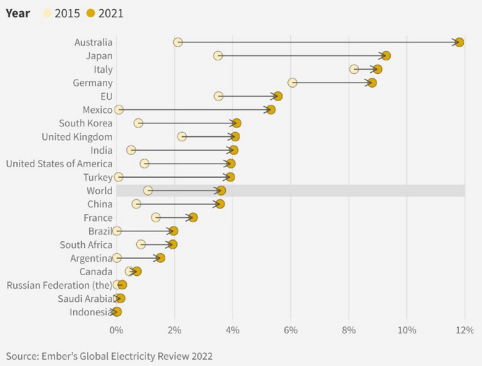
Global solar generation split by country



Share of solar in electricity mix

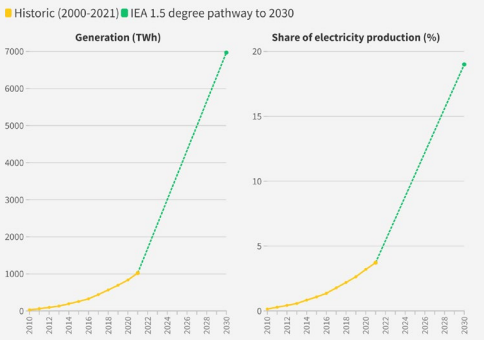


Solar share of electricity generation of G20 countries



Source: Ember's Global Electricity Review 2022

Global solar generation



Source: Ember's Global Electricity Review 2022. IEA Net Zero by 2050 report

Wind

Change in 2021

Global wind generation rose 14% in 2021, rising by 227 TWh to 1,814 TWh. This was the highest % growth rate in four years, and the highest absolute increase ever. It was the fastest-growing source of electricity after solar.

Long term trend

Wind generated 6.6% of the world's electricity in 2021, up from 3.5% in 2015, when the Paris Agreement was signed.

Leaders

China was without doubt the wind leader of 2021. 65% of the growth in global wind generation in 2021 was in China (China's previous highest proportion was 37% of global growth in 2020). It added 148 TWh, the same as the entire electricity demand of Argentina. The large build-out of offshore wind in December 2021 will ensure this growth continues into 2022. Denmark had the biggest share of its electricity from wind (48%); the UK and Germany were both over 20%. Although the EU saw wind generation fall in 2020 due to poor wind speeds, the rate of wind installations hit a new record. Kenya saw the biggest year-on-year rise, from 11% to 16% of its electricity from wind. There are four countries in a race to embrace wind, roughly doubling from 5% of annual generation in 2015 to 10% in 2021: the US (5% to 9%), Australia (5% to 10%), Turkey (4% to 9%) and Brazil (4% to 11%).

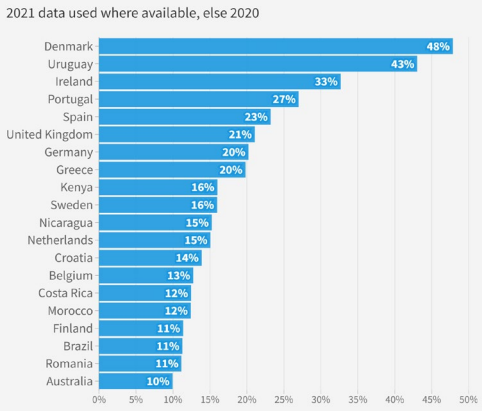
Laggards

Only 1% of global wind generation is in African countries and 0.1% in Middle Eastern countries (having 3% and 4% of global electricity demand respectively). In India, wind generation equalled solar for the first time, having always been in front. South Korea and Japan both had less than 1% of their electricity from wind.

On target for net zero?

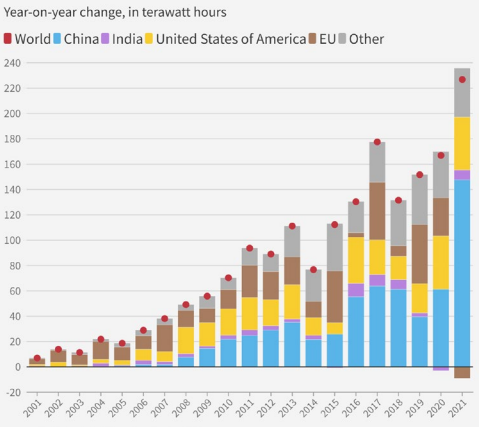
Wind generation needs to rise four-fold by 2030, taking it from 7% of global electricity in 2021 to 21% by 2030. That means maintaining year-on-year growth of 18%; growth last year was 14%, and averaged 15% over the last ten years.

Which countries have the highest wind share of electricity generation?



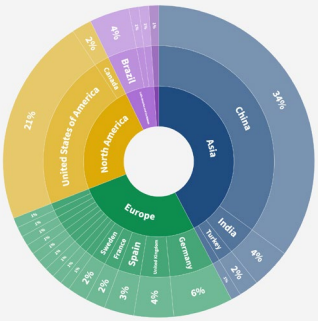
Source: Ember's Global Electricity Review 2022
Note: Countries with populations less than 3 million in 2021 were not included in this ranking.

Annual change in wind generation



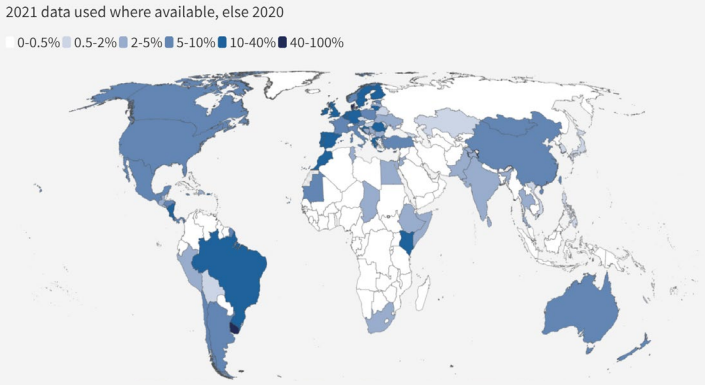
Source: Ember's Global Electricity Review 2022

Global wind generation split by country

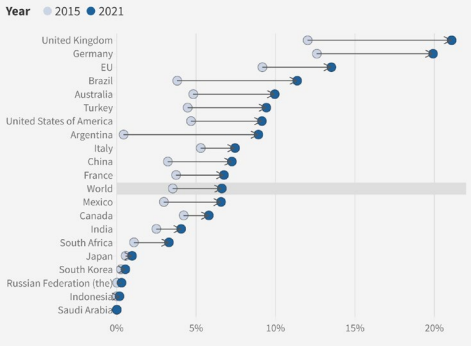


Source: Ember's Global Electricity Review 2022

Share of wind in electricity mix

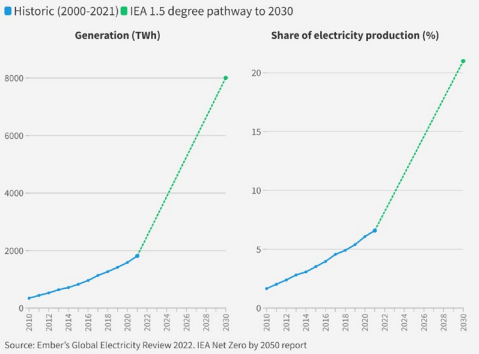


Wind share of electricity generation of G20 countries



Source: Ember's Global Electricity Review 2022

Global wind generation



Source: Ember's Global Electricity Review 2022. IEA Net Zero by 2050 report

Coal

Change in 2021

Coal generation rose by 9% 2021 to an all-time high, beating the previous record set in 2018 by 2%.

Long term trend

Unfortunately coal generation is 10% higher than in 2015 when the Paris Agreement was signed. China's coal generation was 33% higher in 2021 than 2015; the total for the rest of the world fell by 8%. Consequently, China's share of global coal power rose from 44% to 54%.

Leaders

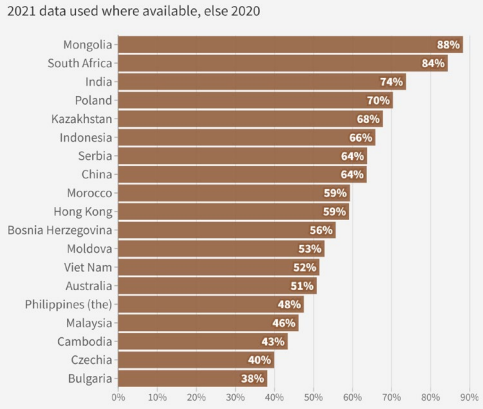
China saw the biggest rise in coal in 2021, rising by 466 TWh, about the same as Japan and South Korea's combined coal power generation in 2021. It was China's fifth year in a row of setting a new coal power record. India is the world's second largest coal power generator, and its coal power increased by 11% in 2021, setting an all-time high by beating the previous record in 2018 by 4%. There were all-time coal power records set in other Asian countries in 2021: Kazakhstan (+6%), Mongolia (+13%), Pakistan (+8%), and the Philippines (+8%).

Most countries in Asia are seeing rapid demand growth, so although absolute coal generation is increasing, the proportion of electricity from coal is actually falling.

On target for net zero?

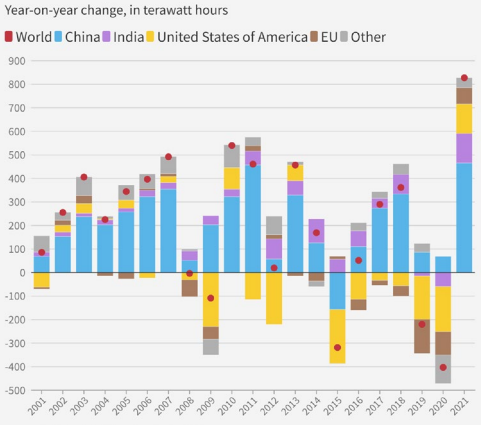
Definitely not. Coal power must fall by 13% every year this decade. That means reducing its share of global electricity from 36% in 2021 to 8% by 2030.

Which countries have the highest coal share of electricity generation?



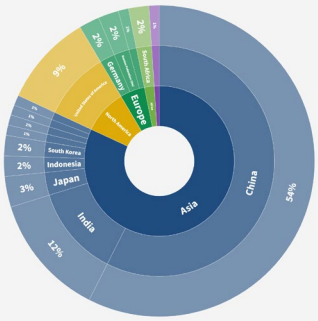
Source: Ember's Global Electricity Review 2022
Note: Countries with populations less than 3 million in 2021 were not included in this ranking.

Annual change in coal generation



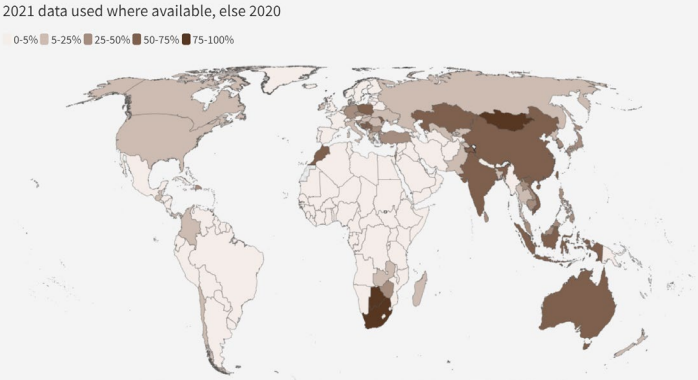
Source: Ember's Global Electricity Review 2022

Global coal generation split by country

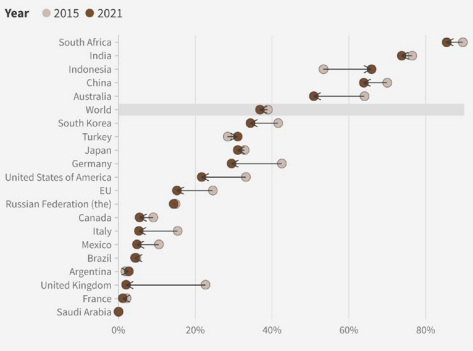


Source: Ember's Global Electricity Review 2022

Share of coal in electricity mix

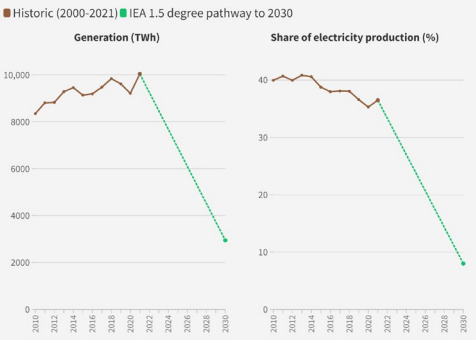


Coal share of electricity generation of G20 countries



Source: Ember's Global Electricity Review 2022

Global coal generation



Source: Ember's Global Electricity Review 2022. IEA Net Zero by 2050 report

Bioenergy

Change in 2021

Global generation from bioenergy rose by 6% in 2021 to 646 TWh. It must be noted that — of all the fuel types — the data on bioenergy is the least reliable.

Long term trend

Bioenergy has increased in line with overall electricity demand since 2015, keeping its share at 2% of global generation. In the same timeframe, solar quadrupled from 1% to 4% and wind almost doubled from 4% to 7%.

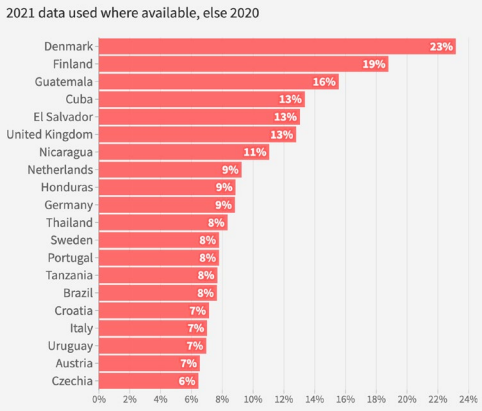
Leaders

China is by far the biggest bioenergy generator. It is also the only country – bar Japan – that is substantially increasing bioenergy production. China's bioenergy generation has tripled since 2015, driving almost two thirds of global growth. Japan leapt past the UK in 2021 to become the #5 biggest bioenergy generator, increasing by 29% in 2021 alone. The other biggest bioenergy generators – the US in #2, Germany in #3 and Brazil #4 – showed nearly no growth from 2015 to 2021.

On target for net zero?

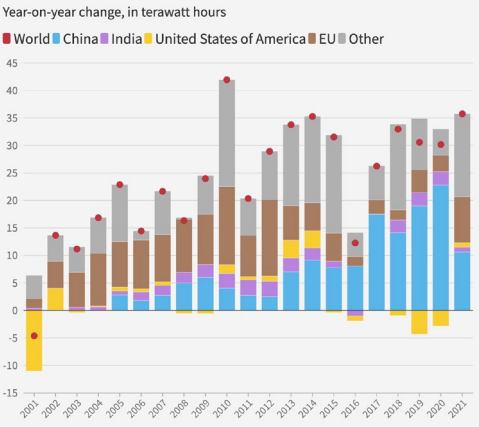
Bioenergy in the IEA's 1.5 degree pathway shows a doubling from 2020 to 2030. That's much faster growth than the last five years, which was 32%. However, the IEA assumes that the bioenergy is low-carbon; but there are big questions as to whether bioenergy is yielding the CO2 reductions it promises. Dependent on sourcing, bioenergy can be very high-carbon. More information is available in our methodology.

Which countries have the highest bioenergy share of electricity generation?



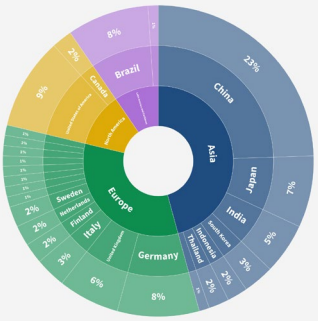
Source: Ember's Global Electricity Review 2022
Note: Countries with populations less than 3 million in 2021 were not included in this ranking.

Annual change in bioenergy generation



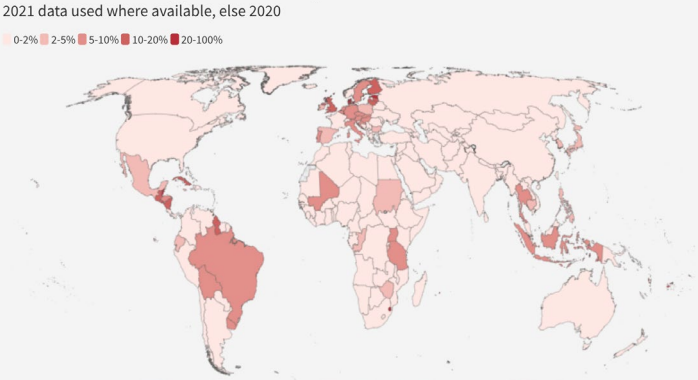
Source: Ember's Global Electricity Review 2022

Global bioenergy generation split by country

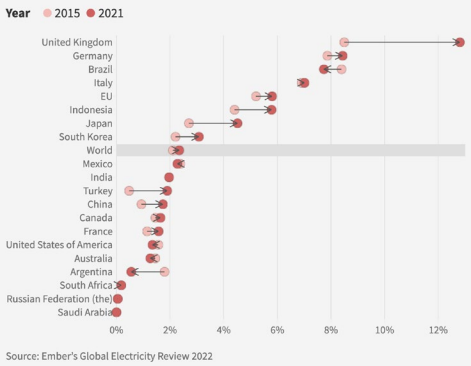


Source: Ember's Global Electricity Review 2022

Share of bioenergy in electricity mix

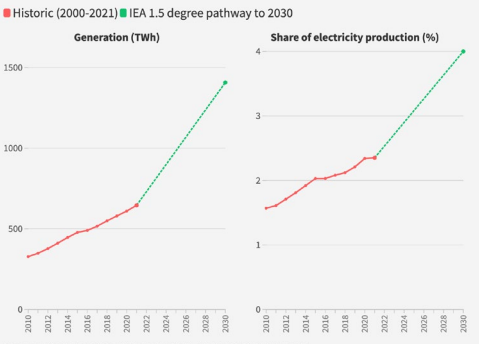


Bioenergy share of electricity generation of G20 countries



Source: Ember's Global Electricity Review 2022

Global bioenergy generation



Source: Ember's Global Electricity Review 2022. IEA Net Zero by 2050 report

Nuclear

Change in 2021

Nuclear electricity generation rose by 4% in 2021 by 100 TWh to 2,736 TWh. France's reactors slightly recovered from a terrible 2020, Japan restarted some reactors, and new reactors came online in China.

Long term trend

The rise in nuclear generation was smaller than the overall rise in electricity demand, so nuclear's market share continued its gradual decline. It generated 17% of global electricity in 2000, and by 2021 this fell to 10%.

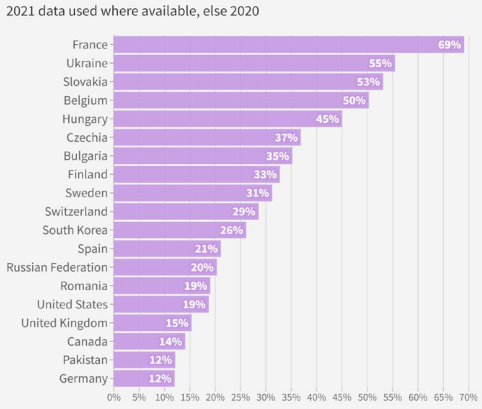
Leaders

China is the only country that is significantly increasing nuclear power as it brings new reactors online. Nuclear generation tripled in seven years to 2021. But nuclear power still only generates 5% of China's electricity. Russia's nuclear generation has been slowly increasing, with a further 2% rise in 2021. Japan's nuclear generation in 2021 rose to the second highest level since Fukushima, as reactors return online. However, generation was still only one-fifth the level back in 2010. France got the largest proportion of its electricity generation from nuclear, at 69% in 2021, followed by Ukraine with 55%.

On target for net zero?

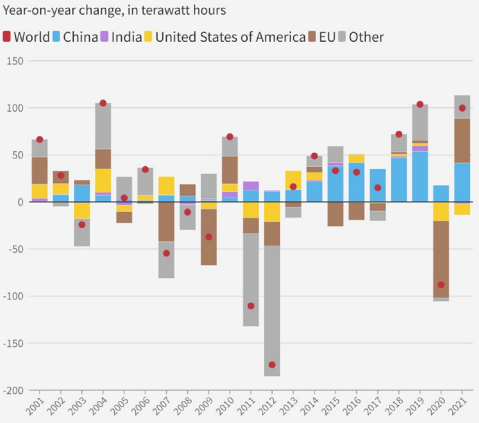
Nuclear generation needs to rise 38% by 2030, according to the IEA's 1.5 degree pathway, keeping its market share unchanged, as electricity demand rises. That means year-on-year growth of 4% from now to 2030. The IEA shows nuclear growing much quicker after 2030.

Which countries have the highest nuclear share of electricity generation?



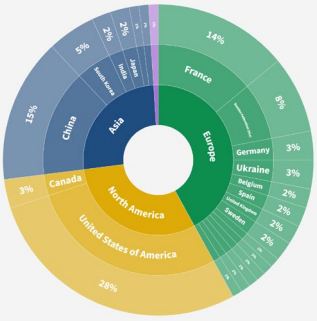
Source: Ember's Global Electricity Review 2022
Note: Countries with populations less than 3 million in 2021 were not included in this ranking.

Annual change in nuclear generation



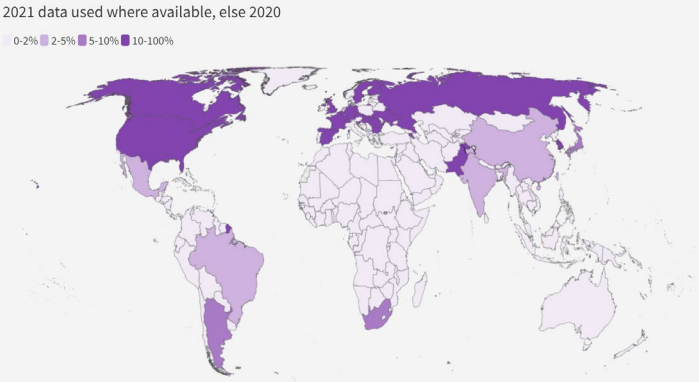
Source: Ember's Global Electricity Review 2022

Global nuclear generation split by country

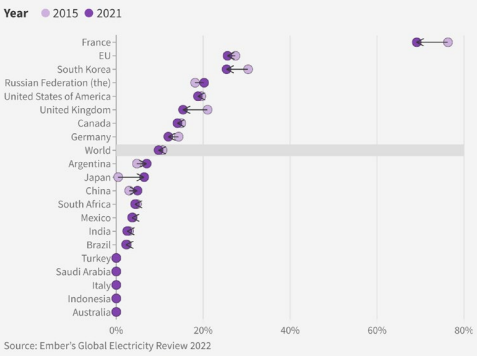


Source: Ember's Global Electricity Review 2022

Share of nuclear in electricity mix

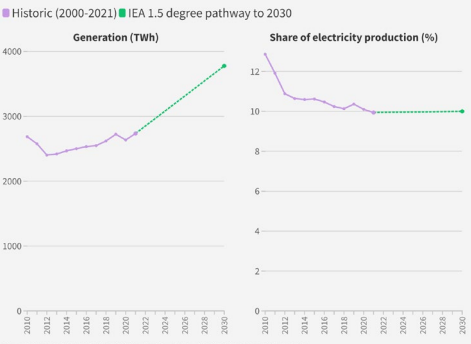


Nuclear share of electricity generation of G20 countries



Source: Ember's Global Electricity Review 2022

Global nuclear generation



Source: Ember's Global Electricity Review 2022, IEA Net Zero by 2050 report

Gas

Change in 2021

Gas generation plateaued, rising by only 1% in 2021 as other electricity sources rose aggressively. It rose by 81 TWh to 6098 TWh. As a consequence, the share of generation dropped from 23% in 2020 to 22% in 2021.

Long term trend

Gases rise has been slow and relentless, leading to a doubling in generation from 2002 to 2020. But with the gas crisis hitting in 2021, causing gas prices to spike to record levels in many countries, generation barely increased. Is this plateau a new trend?

Leaders

The biggest rises in gas in 2021 were in Russia, Turkey and Brazil to compensate for shortfalls in hydro production due to little rain. Most of the countries with the highest amount of their electricity from gas power are in the Middle East and Africa; so as electricity demand in these regions rose, with low levels of clean power investment, gas power also rose.

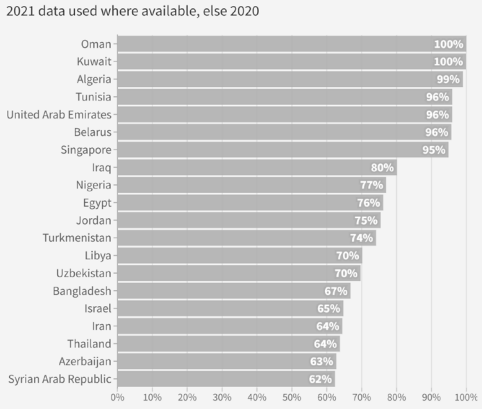
Laggards

Both China and India generated only 3% of their electricity from gas in 2021. However, from 2020 these figures represent a fall of 18% in India and an increase of 8% in China. In China, gas generation has doubled since 2014. The US was responsible for 46% of the rise in global gas generation from 2015 to 2020. But 2021 saw a rare fall due to rising wind, solar and coal generation.

On target for net zero?

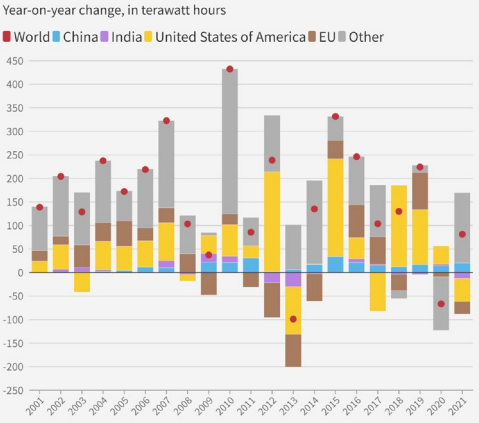
To meet the IEA's 1.5 degree pathway, gas generation in 2030 cannot be significantly higher than it was in 2020. After 2030, unabated gas power must quickly reduce towards zero by 2040.

Which countries have the highest gas share of electricity generation?



Source: Ember's Global Electricity Review 2022
Note: Countries with populations less than 3 million in 2021 were not included in this ranking.

Annual change in gas generation



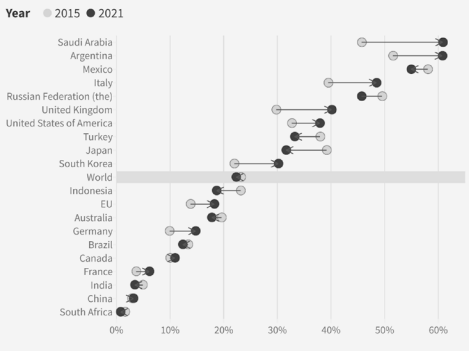
Source: Ember's Global Electricity Review 2022

Global gas generation split by country

Source: Ember's Global Electricity Review 2022

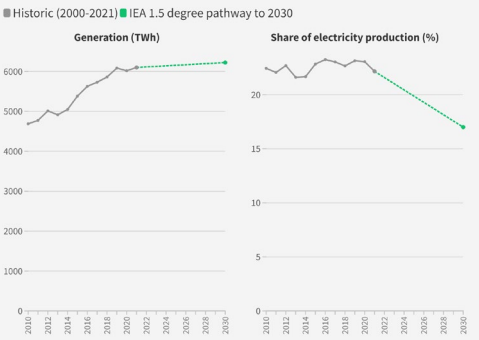
Share of gas in electricity mix

Gas share of electricity generation of G20 countries



Source: Ember's Global Electricity Review 2022

Global gas generation



Source: Ember's Global Electricity Review 2022. IEA Net Zero by 2050 report

Hydro

Change in 2021

Hydro electricity had a 2% fall in production in 2021, due to low rainfall in key countries such as China, Brazil, the US and Turkey.

Long term trend

The rise in hydro generation was smaller than the overall rise in electricity, so hydro's market share continued its gradual decline. It generated 18% of global electricity in 2000, and by 2021 this had slid to only 15%.

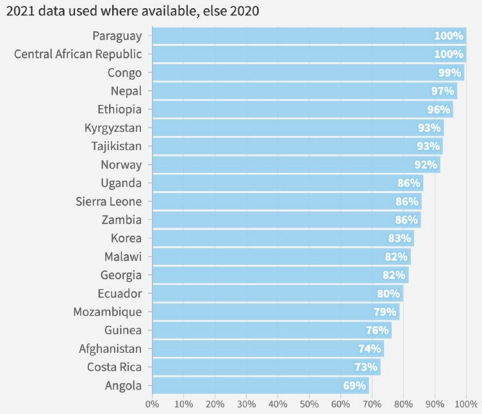
Leaders

China has provided two-thirds of the growth in global hydro electricity generation since 2000, and has three times the generation of the next biggest country, Canada.

On target for net zero?

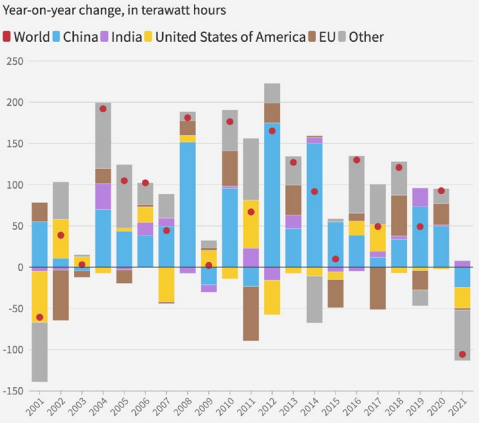
Hydro generation needs to rise 40% by 2030, keeping its market share almost unchanged as electricity demand rises. That means year-on-year growth of 4% from 2021 to 2030. The last ten years grew by 2% on average.

Which countries have the highest hydro share of electricity generation?



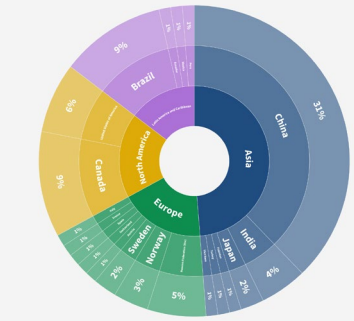
Source: Ember's Global Electricity Review 2022
Note: Countries with populations less than 3 million in 2021 were not included in this ranking.

Annual change in hydro generation



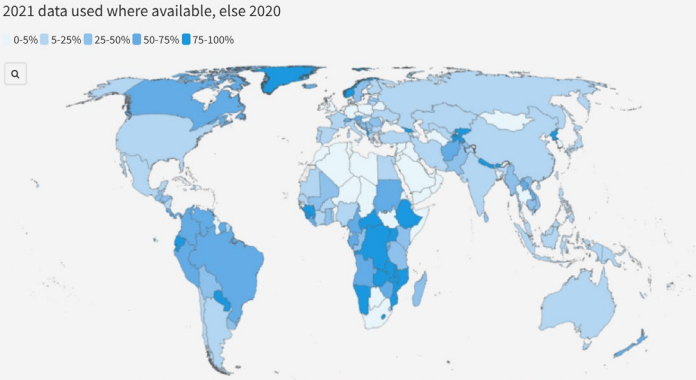
Source: Ember's Global Electricity Review 2022

Global hydro generation split by country

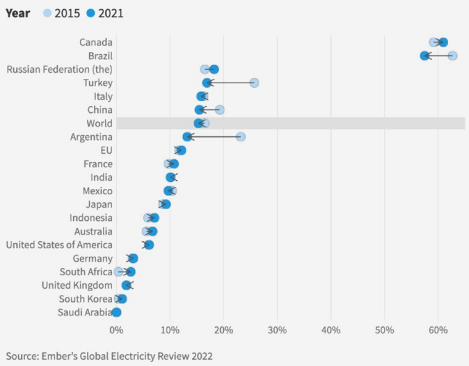


Source: Ember's Global Electricity Review 2022

Share of hydro in electricity mix

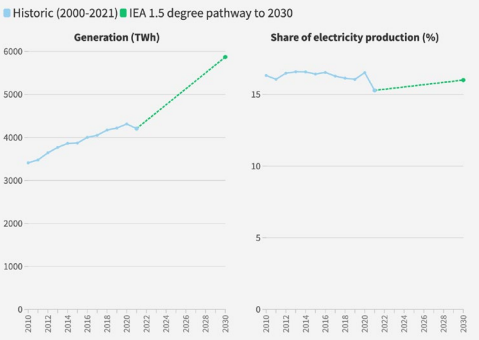


Hydro share of electricity generation of G20 countries



Source: Ember's Global Electricity Review 2022

Global hydro generation



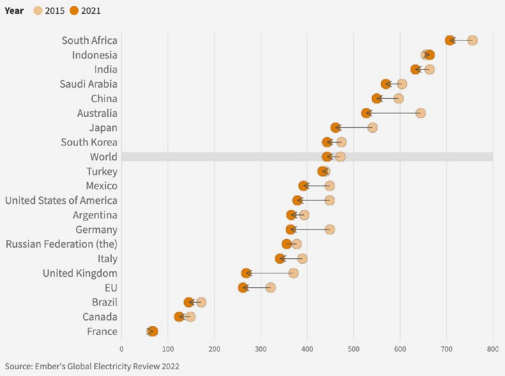
Source: Ember's Global Electricity Review 2022. IEA Net Zero by 2050 report

CO2

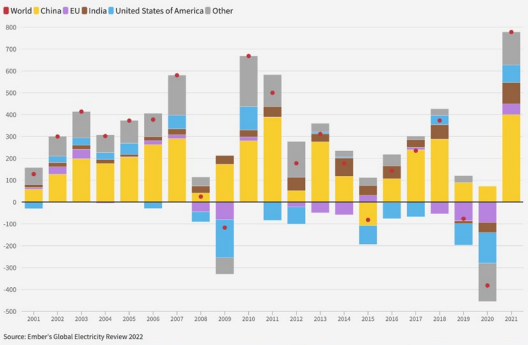
Change in 2021

The record rise in coal, coupled with a modest rise in gas generation, means power sector CO2 emissions rose by 7% (778 million tonnes) in 2021. That's the largest absolute rise ever, and the largest percentage rise since 2010. This rise follows from a fall in 2020, but that fall was only 3%. This takes power sector emissions to a new record of over 12 billion tonnes of CO2, beating the previous record in 2018 by 3%.

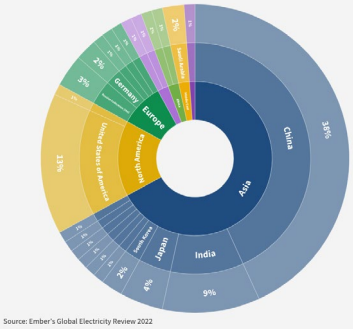
CO2 share of electricity generation of G20 countries



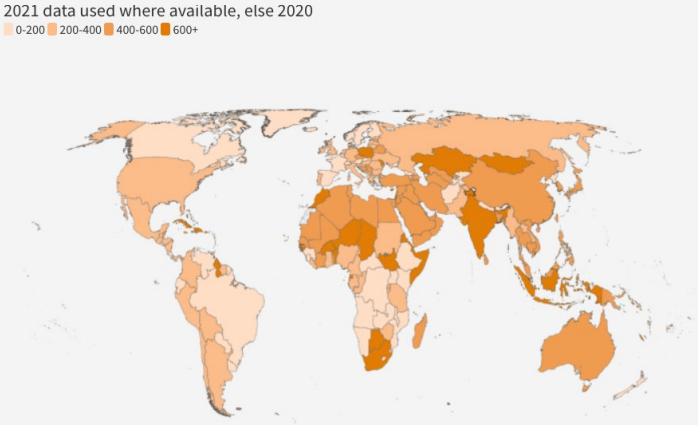
Annual change in CO2 generation



Global CO2 generation split by country



Share of CO2 in electricity mix



The world's electricity got 1% dirtier in 2021, as carbon intensity increased year-on-year from 437 gCO2/KWh to 442. It's the first year since 2011 that the world's electricity was dirtier than the previous year.

Long term trend

Power sector CO2 emissions were 10% higher than in 2015, when the Paris Agreement was signed. However, the CO2 intensity of electricity fell by 6% since 2015. 18 of the G20 countries had cleaner electricity than in 2015.

Leaders

Half of the CO2 emissions rise in 2021 was from China. Australia saw the biggest changes to its electricity carbon intensity of any G20 country since 2015, as solar and wind replaced coal and gas generation. It fell from 644 gCO2/KWh in 2015 to 527 in 2021. It is now slightly less dirty than China's electricity (549 gCO2/KWh in 2021). India also fell (from 663 gCO2/KWh in 2015 633 in 2021), and is now below Indonesia (663 gCO2/KWh in 2021).

On target for net zero?

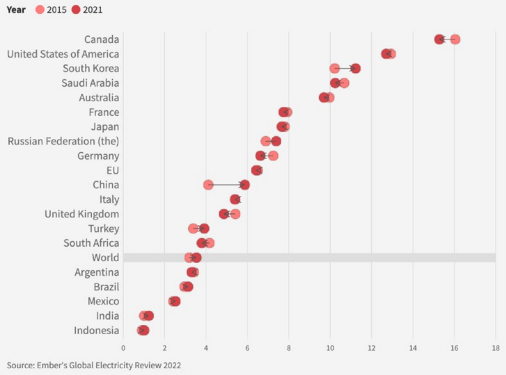
No. The emissions growth is in sharp contrast to what is needed for the IEA's 1.5 degrees pathway: a 60% fall in power sector emissions from 2021 to 2030.

Demand

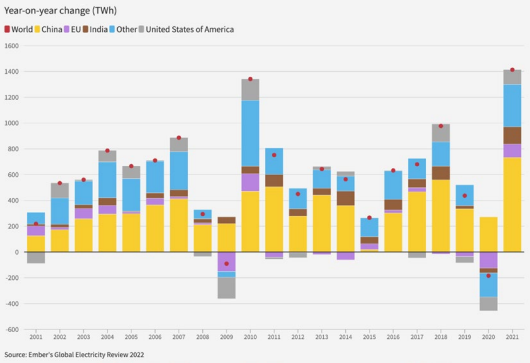
Change in 2021

Electricity demand rose by the most ever in absolute terms: 1,414 TWh from 2020 to 2021 — approximately the equivalent of adding a new India to the world's electricity demand. At 5.4%, 2021 saw the fastest demand growth since 2010. The rise followed from a small 1% fall in 2020. Many advanced countries rebounded after the fall in 2020, back to pre-pandemic levels. The real growth continues to be in Asia, in large part as economic growth boomed. In many countries, it followed on from a growth year even in 2020 when the pandemic struck. China saw the biggest rise, with 13% higher electricity demand in 2021 compared to 2019.

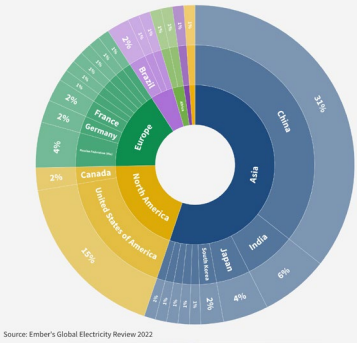
Demand per capita (MWh) among G20 countries



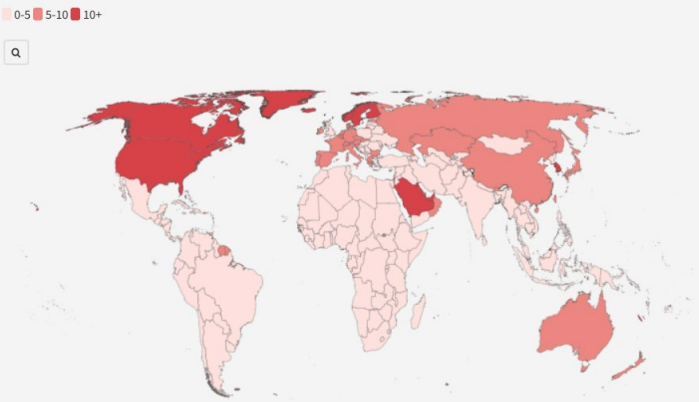
Global change in demand



Distribution of global demand



Demand per capita (MWh)



Long term trend

Countries with the highest electricity demand per capita, such as Canada, the US and Saudi Arabia, have seen a fall compared to 2015, whilst most other countries have seen increases. China has seen by far the largest increase, overtaking the per capita use for both the UK and Italy, though is still behind the US. Roughly speaking, China uses six-times as much electricity per capita as India. However, it is still only half that of electricity-hungry South Korea.

On target for net zero?

What happens to electricity demand is critical for net zero. Electricity demand rises substantially (38%) from 2020 to 2030 in the IEA's 1.5 degree pathway, as the world economy grows, and electrification reduces fuel use in other sectors. But that's in-part offset by a massive expected improvement in efficiency. The large rise in electricity demand in 2021 suggests the world is still not learning to use electricity as efficiently as it needs to.

Supporting Materials

Methodology

Overview

This report analyses annual power generation and import data for 209 countries from 2000 to 2020, with 2021 data included for 75 countries representing 93% of global power demand. Data is collected from multi-country datasets (EIA, Eurostat, BP, UN) as well as national sources (e.g China data from the National Bureau of Statistics). The latest annual generation data is estimated using monthly generation data. Annual capacity data is collected from GEM, IRENA and WRI, and is included for as many countries as it is available for.

All the data can be viewed and downloaded freely from Ember's website. A detailed methodology can be accessed here.

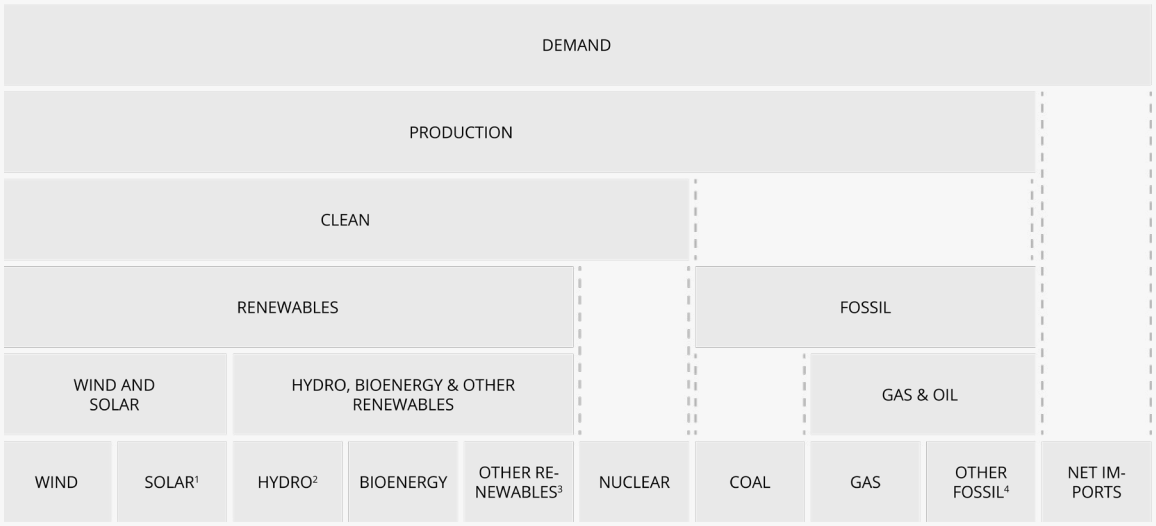
Disclaimer

The data used in this report is provided on an 'as is' basis. Data is assembled using the best available data at the time of publication. Every effort has been made to ensure accuracy, and where possible we compare multiple sources to confirm their agreement. We take no responsibility for errors.

If you notice an issue or have any suggestions, please do contact us at data@ember-climate.org.

Fuel Definitions

Fuel data is mapped into nine generation types: Bioenergy, Coal, Gas, Hydro, Nuclear, Other Fossil, Other Renewables, Solar, and Wind. More information on mapping for different sources and countries can be viewed below.



1. Solar includes both solar thermal and solar photovoltaic generation, and where possible distributed solar generation is included
2. Where possible, hydro generation excludes any contribution from pumped hydro generation
3. Other renewables generation includes geothermal, tidal and wave generation
4. Other fossil generation includes generation from oil and petroleum products, as well as manufactured gases and waste

Bioenergy has typically been assumed (by the IPCC, the IEA, and many others) to be a renewable energy source, in that forest and energy crops can be regrown and replenished, unlike fossil fuels. It is included in many governmental climate targets, including EU renewable energy legislation, and so Ember includes it in “renewable” to allow easy comparison with legislated targets.

However, the climate impact of bioenergy is highly dependent on the feedstock, how it was sourced and what would have happened had the feedstock not been burnt for energy. Current bioenergy sustainability criteria, including those of the EU, generally do not sufficiently regulate out high-risk feedstocks and therefore electricity generation from bioenergy cannot be automatically assumed to deliver

similar climate benefits to other renewables sources. Given the availability of risk-free alternatives to generating electricity such as wind and solar, Ember advocates for countries to minimise or eliminate the inclusion of large-scale bioenergy in the power sector. For more information please see our reports: Understanding the Cost of the Drax BECCS Plant to UK Consumers (May 2021), The Burning Question (June 2020), and Playing with Fire (December 2019).

Methods

Compiling a full dataset from 2000 to 2021 requires using data at multiple timescales. Annual generation data is collected from both national and multi-country sources. For the most recent years, data is often not available. In these cases we use monthly data, which is reported on a shorter lag, to estimate the latest annual generation.

Power data is gathered in a wide variety of formats from multiple sources. In addition to this reconciliation, our data requires considerable cleaning and adjustment of the raw data reported. An overview of our methods is below.

Annual data

Annual data is published with a significant lag, and is generally only available until 2019 or 2020. A number of countries report generation data in 2020 for most but not all fuels. Where this occurs, missing fuels are simply carried forward from the previous year. For net imports, data for missing years is carried forward.

Monthly data

In several cases monthly data is reported on a lagged basis, or data may not be available. In these cases, incomplete months are projected based on both seasonal and interannual trends. Given the unusual nature of power generation during the COVID-19 pandemic, we use 2019 rather than 2020 as a point of reference.

Estimating latest yearly data

Monthly data does not always align with annual data: different types of generation may be included at different scales, or coverage may differ. Where conflicts occur, annual data is generally more accurate. As such, we project latest generation data by applying absolute changes by fuel from available annualised monthly data to

historical annual values. In the few cases where a specific fuel is not available in monthly data, it is treated as having shown no change in the annualised projection. As such, note that simply summing up monthly values **will not produce the same results** as our annual values for any given year.

Thermal disaggregation

Some countries do not report disaggregated generation from fossil fuels. This was performed by Ember using two methods. If possible, the split between fossil fuels was estimated using the ratios of fossil generation in annual data, capacity data or monthly data that provides a split between fuels.

Regional and world estimates

Although our data covers the vast majority of the world's electricity generation for 2021, data is not available for all countries. As such, regional and world figures for this year are estimated. The relative changes in included countries are applied to the latest complete datapoint for a given region and the world to arrive at the estimated value. Electricity imports and exports are not included in estimates for regional or world values.

Emissions data

We report emissions values by fuel type, and emissions intensity by country. These values are calculated by multiplying our generation numbers by emissions factors taken from the IPCC 5th Assessment Report Annex 3 (2014). These figures aim to include full lifecycle emissions including upstream methane, supply-chain and manufacturing emissions, and include all gases, converted into CO2 equivalent over a 100 year timescale.

The emissions intensities we use are below, in carbon dioxide equivalent emitted per kilowatt hour of electricity (gCO2eqkWh−1):

- Coal: 820
- Gas: 490
- Other Fossil: 700
- Wind: 11
- Solar: 48
- Bioenergy: 230

- Hydro: 24
- Other Renewables: 38 (in line with the IPCC's "geothermal")
- Nuclear: 12

IPCC figures still represent the most comprehensive attempt to estimate global fuel emissions intensities. Nonetheless, these emissions factors may differ from reality for a variety of reasons. Please see our complete methodology for more details.

Ember
The Fisheries,
1 Mentmore Terrace,
London Fields,
E8 3PN

Twitter
@EmberClimate

Facebook
/emberclimate

Email
info@ember-climate.org